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# The British Mycological Society

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# TRANSACTIONS

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## Volume XVII

Edited by

J. RAMSBOTTOM, B. F. BARNES and H. WORMALD

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# THE HORSHAM FORAY

## *May 29th–June 2nd*, 1931

By E. M. WAKEFIELD

The 1931 Spring Foray was held at Horsham, Sussex, during the week-end May 29th–June 2nd, with headquarters at the King's Head Hotel. About a dozen members assembled there on the evening of Friday, May 29th.

The first excursion, on Saturday, May 30th, was to Tilgate Forest, by kind permission of Mr C. G. A. Nix. Here, in the grounds of the house, one of the first fungi pointed out was the "Jew's Ear," *Auricularia auricula-Judae*, growing on dead stems of a large *Berberis*. The owner was much relieved on being assured that the fungus was not likely to destroy the Barberry. Not far away, a ditch running through a low-lying swampy spot yielded abundant material of *Mitrula phalloides*, and *Sporocybe Azaleae* was found on rhododendrons in the same area. The latter fungus appears to be common wherever rhododendrons are grown to any extent. The most interesting of the larger fungi which turned up during the day were *Collybia extuberans*, *Coprinus Boudieri*, *Omphalia philonotis*, *Aleuria Emileia*, and *A. violacea*. Mr Petch added to the records some interesting microfungi, including *Cephalosporium verticicolum* Petch on *Trichia varia*.

On the Sunday and Monday various parts of St Leonard's Forest were explored, the party dividing up to some extent. Among the more noteworthy species brought in were *Stereum bicolor* and *Urceolella Pteridis* on stems of bracken. The larger fungi were scarce, and microfungi such as the rusts were also relatively few, on account of the lateness of the vegetation after a cold spring.

On the Saturday evening a meeting was held, at which Mr J. Harvey Bloom gave a short and interesting account of Mickleham as a hunting ground for fungi. The paper was a résumé of the author's collecting work for some years, a splendid example of what may be done by any person who will work an area systematically.

The locality for the 1932 Spring Foray was discussed, with a decision in favour of Ludlow, in Shropshire, if it could be arranged. At the close of the meeting hearty votes of thanks were accorded to Mr Bloom for his good offices in arranging for permits from landowners, and to the landowners themselves.

For assistance in the compilation of the attached list of species the Secretary is indebted more especially to Mr Rea, Mr Ramsbottom,

Mr Pearson, and Mr Petch, the latter being responsible for the list of Mycetozoa, as well as for various records of microfungi.

### *Complete List of Species gathered during the Foray*

*T.* = Tilgate Forest; *L.* = St Leonard's Forest; a few species marked *H.* were gathered by Mr Petch near the river at Horsham.

#### HYMENOMYCETES

Armillaria mellea (Vahl) Fr., rhizomorphs only, *T.*
Lepiota amianthina (Scop.) Fr., *T.*
Tricholoma carneum (Bull.) Fr., *L.*
Collybia platyphylla (Pers.) Fr., *T.*, extuberans (Batt.) Fr., *T.*, *L.*
Mycena sanguinolenta (A. & S.) Fr., *T.*, ammoniaca Fr., *L.*
Omphalia philonotis (Lasch) Fr., *T.*, umbellifera (Linn.) Fr., *T.*, *L.*
Marasmius esculentus (Wulf.) Karst., *L.*, dryophilus (Bull.) Karst., *T.*, *L.*
Pluteus cervinus (Schaeff.) Fr., *T.*
Entoloma jubatum Fr., *T.*, sericeum (Bull.) Fr., *T.*
Nolanea pascua (Pers.) Fr., *T.*, proletaria Fr., *L.*, cetrata Schroet., *T.*
Pholiota praecox (Pers.) Fr., *T.*, *L.*, mycenoides Fr., *T.*
Astrosporina asterospora (Quél.) Rea, *T.*, umbrina (Bres.) Rea, *T.*
Galera hypnorum (Schrank) Fr., *T.*, *L.*
Naucoria semiorbicularis (Bull.) Fr., *L.*
Tubaria furfuracea (Pers.) W. G. Sm., *T.*, *L.*, inquilina (Fr.) W. G. Sm., *T.*, pellucida (Bull.) Fr., *T.*
Flammula sapinea Fr., *T.*, carbonaria Fr., *T.*
Cortinarius (Telamonia) hinnuleus (Sow.) Fr., *T.*, *L.*, (Hydrocybe) leucopus (Bull.) Fr., *T.*, *L.*, decipiens (Pers.) Fr., *L.*
Hypholoma fasciculare (Huds.) Fr., *T.*, *L.*, hydrophilum (Bull.) Fr., *T.*
Panaeolus campanulatus (Linn.) Fr., *T.*
Coprinus atramentarius (Bull.) Fr., *L.*, Boudieri Quél., *T.*, plicatilis (Curt.) Fr., *L.*
Boletus erythropus (Pers.) Quél., *L.*
Polyporus squamosus (Huds.) Fr., *L.*, sulphureus (Bull.) Fr., *T.*, betulinus (Bull.) Fr., *T.*, adustus (Willd.) Fr., *L.*, caesius (Schrad.) Fr., *L.*
Fomes ferruginosus (Schrad.) Mass., *T.*, *L.*
Ganoderma applanatum (Fr.) Pat., *T.*
Polystictus versicolor (Linn.) Fr., *T.*, *L.*, abietinus (Dicks.) Fr., *T.*
Irpex obliquus (Schrad.) Fr., *T.*, *L.*
Trametes gibbosa (Pers.) Fr., *L.*, rubescens (A. & S.) Fr., *T.*, *L.*
Daedalea quercina (Linn.) Fr., *T.*, *L.*
Grandinia farinacea (Pers.) Bourd. & Galz., *T.*, *L.*
Odontia barba-Jovis (With.) Fr., *L.*, papillosa (Fr.) Bres., *L.*
Thelephora terrestris Fr., *T.*
Hypochnus fuscus (Pers.) Fr., *T.*, *L.*, fumosus Fr., *T.*
Stereum rugosum (Pers.) Fr., *L.*, hirsutum (Willd.) Fr., *T.*, *L.*, bicolor (Pers.) Fr., *L.*
Hymenochaete rubiginosa (Dicks.) Lév., *T.*, corrugata (Fr.) Lév., *L.*
Corticium microsporum (Karst.) Bourd. & Galz., *L.*, subcoronatum v. Hoehn. & Litsch., *T.*, *L.*, botryosum Bres., *T.*, *L.*, confine Bourd. & Galz., *L.*, comedens (Nees) Fr., *L.*, roseocremeum Bres., *L.*, praetermissum (Karst.) Bres., *L.*, porosum B. & C., *L.*
Peniophora glebulosa (Fr.) Bres., *T.*, *L.*, subalutacea (Karst.) v. Hoehn. & Litsch., *L.*, pallidula Bres., *T.*, sanguinea (Fr.) Bres., *T.*, cremea Bres., *L.*, velutina (DC.) Cooke, *L.*, setigera (Fr.) Bres., *L.*, hydnoides Cooke & Mass., *T.*, *L.*, cinerea (Fr.) Cooke, *T.*, quercina (Pers.) Cooke, *T.*, mollis (Fr.) Bres., *T.*

Auricularia auricula-Judae (Linn.) Schroet., on *Berberis*, *T.*
Dacryomyces deliquescens (Bull.) Duby, *L.*
Calocera cornea (Batsch) Fr., *L.*

## GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *T.*, *L.*

## UREDINALES

Uromyces Scillarum (Grev.) Wint., *L.*
Puccinia Violae (Schum.) DC., *T.*, *L.*, Circaeae Pers., *L.*, obtegens (Link) Tul., *H.*, Primulae (DC.) Duby, *L.*, Caricis (Schum.) Rebent., *T.*
Phragmidium Rubi (Pers.) Wint., *T.*
Pucciniastrum Epilobii (Pers.) Otth, *H.*

## USTILAGINALES

Tilletia striiformis (Westend.) Magn., on *Holcus*, *T.*

## PYRENOMYCETES

Sphaerotheca pannosa (Wallr.) Lév., *T.*
Hypomyces rosellus (A. & S.) Tul., *T.*
Stigmatea Robertiani Fr., *T.*
Melanconis stilbostoma (Fr.) Tul., on *Betula*, *L.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not., on *Betula*, *L.*
Diatrype Stigma (Hoffm.) Fr., *T.*, disciformis (Hoffm.) Fr., on *Fagus*, *L.*
Diatrypella quercina (Pers.) Nits., *L.*
Ustulina vulgaris Tul., on *Fagus*, *T.*
Hypoxylon coccineum Bull., on *Fagus*, *L.*, multiformis Fr., *T.*
Xylaria Hypoxylon (Linn.) Grev., *L.*
Endodothella Junci (Fr.) Theiss. & Syd., *T.*
Rhopographus Pteridis (Sow.) Wint., *T.*

## DISCOMYCETES

Acetabula vulgaris Fuck., *L.*
Aleuria violacea (Pers.) Gill., *T.*, Emileia (Cooke) Boud., *T.*
Anthracobia melaloma (A. & S.) Boud., *T.*
Ascobolus denudatus Fr., *T.*
Mitrula phalloides (Bull.) Chev., *T.*
Orbilia xanthostigma Fr., *T.*
Sclerotinia Curreyana (Berk.) Karst., sclerotium only, *T.*
Chlorosplenium aeruginosum (Oeder) de Not., on *Betula*, *T.*, *L.*
Dasyscypha virginea (Batsch) Fuck., *T.*, *L.*
Arachnopeziza aurelia (Pers.) Fuck., *T.*, aurata Fuck., *L.*
Hyaloscypha hyalina (Pers.) Boud., *T.*, *L.*
Urceolella Pteridis (A. & S.) Boud., *L.*
Mollisia cinerea (Batsch) Karst., *T.*

## DEUTEROMYCETES

Libertella faginea Desm., on *Fagus*, *L.*
Ovularia obliqua (Cooke) Oud., *T.*, *L.*
Botrytis cinerea Pers., *L.*
Acremonium album Preuss, on *Trichia affinis*, *T.*, on *Trichia varia* and *Comatricha nigra*, *L.*
Cephalosporium verticicolum Petch, on *Trichia varia*, *T.*
Sporotrichum Isariae Petch, on *Isaria farinosa*, *L.*
Rhinotrichum repens Preuss, *L.*

Ramularia Primulae Thuem., *T.*, *L.*, Circaeae Allesch., *L.*
Trichoderma viride (Pers.) Fr., *L.*
Bispora monilioides Corda, *L.*
Sporocybe Azaleae (Peck) Sacc., *T.*
Isaria farinosa (Dicks.) Fr., *T.*, *L.*

## MYCETOZOA

Ceratiomyxa fruticulosa Macbr., *T.*, *L.*,
Comatricha nigra Schroet., *L.*
Stemonitis fusca Roth, *T.*
Lycogala epidendrum Fr., *T.*, *L.*
Trichia varia Pers., *T.*, *L.*, affinis de Bary, *T.*, persimilis Karst., *L.*
Arcyria denudata Wetts., *T.*, cinerea Pers., *L.*

# THE BELFAST FORAY

## *September 5th–12th*, 1931

By E. M. WAKEFIELD

The thirty-fifth Autumn Foray and Annual General Meeting was held at Belfast, at the invitation of the botanists of Northern Ireland, during the week September 5th–12th.

By kind permission of the University authorities, the Agricultural Buildings in Elmwood Avenue were placed at the disposal of the Society. Here there was ample room in one of the laboratories for the display of specimens, and in another laboratory were provided microscopes and books, so that critical work could be carried on apart from the exhibition.

Most of the English members arrived early on the Saturday morning, after a somewhat uneasy crossing, and were glad of a restful time until midday. After lunch, however, the splendidly organised formal programme began, and the whole of the time for the week was well filled.

In some respects the arrangements during this foray differed from those which usually obtain. On three of the days two forays took place, one a long one and the other comparatively short. In this way members were able to choose the sort of excursion which most appealed to them, and at the same time the records benefited by the exploration of a greater area than would otherwise have been possible. Then again, owing to the time necessary for most of the excursions, and also the distance of headquarters from the hotel, it was not easy to arrange for work each day on the finds of the previous day. For this reason two days, the Wednesday and Saturday, were kept free from formal excursions, and could be entirely utilised for critical work by those who wished to do this.

The first excursion, after an early lunch on the day of arrival, was taken in conjunction with the Belfast Naturalists' Field Club, to Mount Stewart, the seat of the Marquess of Londonderry. A number of records was made, but there was nothing calling for special mention. The excursion was mainly of the nature of a sight-seeing expedition, the gardens at Mount Stewart providing much interest. It was especially remarkable to see fine eucalyptus trees and a specimen of the dragon tree thriving in the open. The party was entertained to tea at Newtownards on the return journey. In the evening the Learned Societies of Belfast gave a dinner to members of the British Mycological Society at the Grand Central Hotel, Belfast.

On Sunday, September 6th, an afternoon excursion was arranged to Glenariff, one of the beautiful glens of Antrim. The party was

taken by motor-coaches, and the route chosen provided an opportunity of seeing some beautiful scenery, especially that of the Antrim coast. The glen itself, besides eliciting admiration for its beauty, somewhat akin to that of parts of North Wales, provided good fungus hunting. Many members regretted that the time allowed here was so short. One of the first finds was *Clavaria formosa*, a fine specimen at the foot of a waterfall. *Hygrophorus agathosmus* var. *aureofloccosus* Bres., new to Britain, was the best find of the day, but several interesting species of *Inocybe* were recorded. The moist atmosphere of the glen appeared to be particularly favourable to leaf parasites, and among others *Mycosphaerella depazeaeformis*, on leaves of *Oxalis*, occurred abundantly.

On Monday, September 7th, two excursions took place, one to Clandeboye, and a shorter one to Belvoir Park, along the river Lagan. Both areas provided many species of Agaricaceae, so that by the end of the day the exhibits began to look considerable.

The Tuesday excursions were again doubled, one party going to Baronscourt, about eighty miles away, the seat of the Duke of Abercorn, while the other visited Shane's Castle, the ancestral home of the O'Neills, on the shores of Lough Neagh. Those who took part in the Shane's Castle excursion felt that this was one of the most delightful days of the week. Fungi were here, too, in plenty, and this was one of the most productive localities for the resupinate Basidiomycetes. *Hygrophorus Wynniae* (in abundance amongst moss at the foot of an old larch), *Pholiota erebia*, and *Naucoria centunculus* were among the more noteworthy Agaric finds of this day,

In the evening, at headquarters, the President, Mr A. A. Pearson, F.L.S., delivered his Address, entitled "Modern European Work on the Hymenomycetes."

As already mentioned, Wednesday was kept as a free day, and several members were glad of the opportunity to go through the collections and do some microscopic work. A small party visited the Linen Industry Research Station at Lambeg, where they were shown the various processes involved in the transformation of flax fibre into linen. Yet a few other members used the day to visit the Giant's Causeway, and the few records from this district, which are entered in the attached list, are due to Mr Ramsbottom.

On Wednesday evening, Colonel C. Theodore Green delivered a public popular lecture on the larger fungi, in the Municipal Museum.

On Thursday, September 10th, two forays again took place. The long one was to Tollymore Park, Co. Down, with a short detour on the homeward journey to the foot of the Mourne Mountains. The shorter foray was to Rademon, near Crossgar, Co. Down. At Tollymore the moist conditions again favoured microfungi, and some particularly fine material of *Milesina Blechni* Syd. was obtained.

Among the larger fungi, abundant material of *Craterellus pusillus* gave rise to some discussion, for the largest specimens appeared almost indistinguishable from *Cantharellus cinereus*. When it is realised that the spore characters of these two species are alike, there seems good reason to doubt if there is any real distinction, although on hymenial characters they have been placed in different genera. *Leptonia solstitialis* was another noteworthy find at Tollymore. The Rademon excursion yielded numerous Hymenomycetes, and *Melanogaster variegatus*. A few species collected at Downpatrick, on the homeward journey from Tollymore Park, where St Patrick's tomb was visited, are included in the following lists.

On Friday evening, Mr Ramsbottom delivered a popular lecture on general mycology at the Municipal Museum.

The last formal excursion of the week, on Friday, September 11th, was to Hillsborough, Co. Down, where the Agricultural Research Institute for Northern Ireland is situated. Appropriately enough, this day was particularly noteworthy for the abundance of parasitic fungi, both on wild plants and on cultivated crops. *Naumovia abundans* on *Prunella* justified its specific name. *Urocystis Anemones* on *Ranunculus repens* was remarkably fine, and Ergot was conspicuous on several wild grasses, particularly on *Phleum pratense*. One of the most interesting records of the week was first noticed by Dr P. O'Connor—a delicate white *Corticium* causing brown patches and distortion of bracken fronds in a damp spot. Careful observation revealed the presence of sclerotia, which by subsequent cultural work have been proved to belong to the *Corticium*. The species concerned was named "*Tulasnella anceps*" by Bresadola and Sydow, and is included under this name in the attached list. There is no doubt however that it is nearer to *Corticium* than to *Tulasnella*. It has transpired that the same fungus is the cause of a bracken disease in Scotland, which is under investigation by Mrs M. J. F. Gregor, of the Royal Botanic Garden, Edinburgh. At the close of the day the members were entertained to tea at the Agricultural Research Institute, and were shown the work in progress there.

Many of the party left Belfast on Friday night, but those who stayed over the week-end added to the lists, and to Mr Rea in particular are due the records from Dunfanaghy and Tardree.

At the Annual General Meeting of the Society, held on Monday evening, September 7th, the officers for 1932 were elected as follows: President, Miss G. Lister; Vice-Presidents, Mr A. A. Pearson and Miss A. Lorrain Smith; new members of Council, Mr A. E. Muskett, Mr F. G. Gould and Miss C. A. Cooper. The other officers remain as before. Mr F. A. Mason was nominated as delegate to the British Association in 1932. For the 1932 Autumn Foray Haslemere was selected, at the invitation of Mr E. W. Swanton. It was decided to

add to the Rules one defining the status and aims of the Plant Pathology Committee.

Finally, at the close of the meeting, very hearty votes of thanks were passed to the landowners who had given permission for such delightful excursions, to the Learned Societies of Belfast for their hospitality, to the University authorities for permission to use the Agricultural Laboratories, and above all to Mr Muskett and his colleagues for the admirable arrangements made.

Owing to the numerous localities visited the compilation of the attached list was more difficult than usual, and the Secretary is particularly indebted for help to Mr Muskett, Mr Pearson, Mr Ramsbottom, Mr Rea and Dr Alex Smith. In a few cases isolated specimens were found put out on the tables with no indication of where they were gathered. These are marked as "unlocalised." Fortunately such cases were very few, and correlation of all the lists kept has enabled most records to be given accurately as to county. It will be noted that three of the counties of Ulster are included in these records, namely Antrim, Down, and Tyrone. Many of the species recorded were new to Ulster, and about sixty new to Ireland, while three, *Boletus pulverulentus*, *Hygrophorus agathosmus* var. *aureofloccosus*, and *Tulasnella anceps*, are new to Great Britain.

### *Complete List of Species gathered during the Foray*

*B.* = Baronscourt, Co. Tyrone; *C.* = Clandeboye, Co. Down; *G.* = Glenariff, Co. Antrim; *H.* = Hillsborough, Co. Down; *L.* = Belvoir Park, Co. Down; *M.* = Mount Stewart, Co. Down; *R.* = Rademon, Co. Down; *S.* = Shane's Castle, Co. Antrim; *T.* = Tollymore Park, Co. Down; *D.* = Dunfanaghy, Co. Donegal; *A.* = Tardree, Co. Antrim.

#### HYMENOMYCETES

Amanita verna (Lam.) Fr., *T.*, phalloides (Vaill.) Fr., *C.*, *B.*, mappa (Batsch) Fr., *B.*, *R.*, *T.*, muscaria (Linn.) Fr., *R.*, pantherina (DC.) Fr., *T.*, spissa Fr., *L.*, *B.*, rubescens (Pers.) Fr., *C.*, *B.*, *R.*, *H.*, *T.*

Amanitopsis vaginata (Bull.) Roze, *G.*, *C.*, *B.*, *L.*, fulva (Schaeff.) W. G. Sm., *H.*

Lepiota procera (Scop.) Fr., *R.*, rhacodes (Vitt.) Fr., *R.*, *L.*, amianthina (Scop.) Fr., *L.*, *R.*, granulosa (Batsch) Fr., *H.*

Armillaria mellea (Vahl) Fr., *C.*, *S.*, *L.* (rhizomorphs only), *B.*, *T.*, *H.*, mucida (Schrad.) Fr., *M.*, *C.*, *S.*, *L.*, *B.*, *H.*

Tricholoma resplendens Fr., *M.*, *H.*, *T.*, albobrunneum (Pers.) Fr., *M.*, *H.*, rutilans (Schaeff.) Fr., *A.*, *B.*, *S.*, *R.*, *H.*, imbricatum Fr., *Hazelwood Glen*, terreum (Schaeff.) Fr., *M.*, *B.*, *H.*, argyraceum (Bull.) Fr., *B.*, *M.*, murinaceum (Bull.) Fr., *M.*, atromarginatum Bres., *H.*, saponaceum Fr., *H.*, *T.*, album (Schaeff.) Fr., *H.*, *C.*, cinerascens (Bull. non Fr.) Quél., *G.*, *H.*, *R.*, melaleucum (Pers.) Fr., *D.*

Clitocybe infundibuliformis (Schaeff.) Fr., *T.*, flaccida (Sow.) Fr., *R.*, *H.*, aurantiaca (Wulf.) Studer, *R.*, vibecina Fr., *A.*, metachroa (Fr.) Berk., *A.*

Laccaria laccata (Scop.) B. & Br., *A.*, *B.*, *M.*, *C.*, *S.*, *R.*, *T.*, and var. amethystina (Vaill.) B. & Br., *C.*, *M.*, *B.*, *S.*, *H.*, *T.*

Collybia radicata (Relh.) Berk., *C.*, *T.*, platyphylla (Pers.) Fr., *R.*, maculata (A. & S.) Fr., *B.*, distorta Fr., *unlocalised*, butyracea (Bull.) Fr., *A.*

Mycena pura (Pers.) Fr., *A.*, *R.*, *T.*, luteoalba (Bolt.) Fr., *D.*, virens (Bull.) Quél., *H.*, gypsea Fr., *H.*, rugosa Fr., *unlocalised*, galericulata (Scop.) Fr., *R.*, *L.*, *T.*, polygramma (Bull.) Fr., *T.*, alcalina Fr., *T.*, pullata Berk. & Cooke, *T.*, ammoniaca Fr., *A.*, *C.*, *L.*, *S.*, *T.*, metata Fr., *H.*, *T.*, plicosa Fr., *H.*, stannea Fr., *T.*, filopes (Bull.) Fr., *B.*, amicta Fr., *L.*, *T.*, Iris Berk., *R.*, *S.*, vitilis Fr., *L.*, *T.*, acicula (Schaeff.) Fr., *G.*, *C.*, *S.*, *T.*, haematopus (Pers.) Fr., *M.*, *C.*, *B.*, *S.*, *L.*, *H.*, *T.*, sanguinolenta (A. & S.) Fr., *B.*, *H.*, *T.*, galopus (Pers.) Fr., *A.*, *M.*, *B.*, *S.*, *L.*, *T.*, var. alba Fl. Dan. *B.*, *L.*, var. nigra Fl. Dan., *L.*, tenerrima Berk., *R.*, *T.*

Omphalia atropuncta (Pers.) Quél., *G.*, umbellifera (Linn.) Fr., *B.*, velutina Quél., *G.*, fibula (Bull.) Fr., *M.*, *H.*, pyxidata (Bull.) Fr., *D.*

Russula chloroides (Krombh.) Bres., *G.*, *M.*, *C.*, *B.*, *S.*, *R.*, *H.*, nigricans (Bull.) Fr., *M.*, *C.*, *B.*, *R.*, *L.*, *H.*, *T.*, adusta (Pers.) Fr., *G.*, *R.*, and var. coerulescens Fr., *T.*, densifolia (Secr.) Gill., *H.*, virescens (Schaeff.) Fr., *G.*, *M.*, lepida Fr., *M.*, *S.*, *B.*, *L.*, *H.*, *T.*, cyanoxantha (Schaeff.) Fr., *M.*, *G.*, *L.*, *B.*, *R.*, *T.*, *H.*, furcata (Pers.) Fr., *M.*, heterophylla Fr., *R.*, *T.*, foetens (Pers.) Fr., *R.*, *L.*, *T.*, *H.*, ochroleuca (Pers.) Fr., *M.*, *C.*, *S.*, *B.*, *L.*, *T.*, *A.*, fellea Fr., *M.*, *C.*, *R.*, *L.*, *S.*, *B.*, *A.*, *T.*, *H.*, drimeia Cooke, *M.*, *C.*, *L.*, *B.*, *S.*, *R.*, and var. Queletii (Fr.) Bat., *M.*, *C.*, fragilis (Pers.) Fr., *R.*, *B.*, *L.*, *T.*, *H.*, and var. nivea (Pers.) Cooke, *T.*, emetica (Schaeff.) Fr., *M.*, *L.*, *R.*, *B.*, *T.*, *H.*, atropurpurea (Krombh.) Maire, *M.*, *T.*, *H.*, and var. depallens (Cooke) Maire, *M.*, *R.*, xerampelina (Schaeff.) Fr., *T.*, grisea (Pers.) Bres., *R.*, *H.*, fusca Quél., *M.*, *C.*, puellaris Fr., *R.*, *T.*, alutacea (Pers.) Fr. var. olivascens (Fr.) Rea, *unlocalised*, vesca Fr., *M.*, *C.*, *L.*, *R.*, punctata (Gill.) Maire, *Shaw's Bridge, Belfast*, caerulea Cooke, *G.*, *M.*, *L.*, *A.*, lutea (Huds.) Fr., *G.*, *M.*, *L.*

Lactarius torminosus (Schaeff.) Fr., *C.*, *T.*, *B.*, turpis (Weinm.) Fr., *L.*, *R.*, blennius Fr., *M.*, *G.*, *C.*, *S.*, *B.*, *L.*, *T.*, *H.*, pyrogalus (Bull.) Fr., *M.*, *C.*, *T.*, vellereus Fr., *G.*, *R.*, *B.*, deliciosus (Linn.) Fr., *M.*, *B.*, *Hazelwood Glen*, *R.*, pallidus (Pers.) Fr., *C.*, *L.*, *T.*, quietus Fr., *C.*, *R.*, *H.*, *T.*, aurantiacus (Fl. Dan.) Fr., *L.*, theiogalus (Fr.) Plowr., *M.*, rufus (Scop.) Fr., *C.*, *S.*, glyciosmus Fr., *M.*, *R.*, *T.*, *H.*, *L.*, fuliginosus Fr., *H.*, *T.*, spinulosus Quél., *C.*, serifluus (DC.) Fr., *B.*, *T.*, mitissimus Fr., *M.*, *R.*, *B.*, *T.*, subdulcis (Pers.) Fr., *G.*, *L.*, *R.*, *B.*, *H.*, *T.*, camphoratus (Bull.) Fr., *T.*

Pleurotus ostreatus (Jacq.) Fr., *L.*, *R.*, sapidus Schulz., *L.*

Hygrophorus olivaceoalbus Fr., *C.*, agathosmus Fr., var. aureofloccosus* Bres., *G.*, pratensis (Pers.) Fr., *C.*, *H.*, *D.*, virgineus (Wulf.) Fr., *M.*, *D.*, Colemannianus Blox., *D.*, laetus (Pers.) Fr., *T.*, ceraceus (Wulf.) Fr., *C.*, *S.*, *T.*, *A.*, coccineus (Schaeff.) Fr., *M.*, *G.*, *C.*, *D.*, *A.*, miniatus Fr., *T.*, Wynniae B. & Br., *C.*, *S.*, puniceus Fr., *A.*, *D.*, conicus (Scop.) Fr., *T.*, *H.*, *D.*, chlorophanus Fr., *D.*, *A.*, psittacinus (Schaeff.) Fr., *T.*, *H.*, *D.*, *A.*, unguinosus Fr., *C.*

Cantharellus cibarius Fr., *T.*, *M.*, tubaeformis Fr., *T.*

Nyctalis parasitica (Bull.) Fr., *B.*, *T.*

Marasmius peronatus (Bolt.) Fr., *B.*, *H.*, *T.*, oreades (Bolt.) Fr., *S.*, *B.*, esculentus (Wulf.) Karst., *S.*, *R.*, hariolorum (DC.) Quél., *M.*, *S.*, *R.*, *T.*, dryophilus (Bull.) Karst., *M.*, *R.*, *B.*, *H.*, *T.*, ramealis (Bull.) Fr., *B.*, *L.*

Androsaceus rotula (Scop.) Pat., *B.*, *A.*, androsaceus (Linn.) Pat., *B.*, epiphylloides Rea, *H.*

Panus torulosus (Pers.) Fr., *C.*, stipticus (Bull.) Fr., *T.*

Lentinus cochleatus (Pers.) Fr., *H.*

Pluteus cervinus (Schaeff.) Fr., *M.*, *C.*, *S.*, *B.*, *L.*

Entoloma lividum (Bull.) Fr., *C.*, rhodopolium Fr., *S.*, nidorosum Fr., *R.*, *B.*, sericeum (Bull.) Fr., *D.*, *A.*

Nolanea pascua (Pers.) Fr., *B.*, *H.*, *T.*, *A.*, *D.*, papillata Bres., *M.*, *T.*, proletaria Fr., *M.*, *R.*, *A.*, cetrata (Fr.) Schroet., *A.*

Leptonia lampropus Fr., *C.*, solstitialis Fr., *T.*, chalybea (Pers.) Fr., *T.*, sericella (Fr.) Quél., *T.*

Clitopilus prunulus (Scop.) Fr., *C.*, *L.*, *R.*, *T.*

* New to Britain.

Claudopus variabilis (Pers.) W. G. Sm., *A.*, *S.*
Paxillus involutus (Batsch) Fr., *M.*, *C.*, *B.*, *R.*, *H.*, *A.*
Pholiota erebia Fr., *S.*, squarrosa (Müll.) Fr., *S.*, spectabilis Fr., *S.*, *B.*, *H.*, flammans Fr., *L.*, *S.*, mutabilis (Schaeff.) Fr., *G.*, *C.*, *R.*, *H.*, marginata (Batsch) Fr., *S.*, *B.*
Inocybe pyriodora (Pers.) Fr., *G.*, *A.*, corydalina Quél., *G.*, *Hazelwood Glen*, geophylla (Sow.) Fr., *M.*, *G.*, *C.*, *L.*, *T.*, *A.*, and var. lilacina Fr., *S.*, *C.*, descissa Fr., *H.*, Godeyi Gill., *G.*, lacera Fr., *S.*, *L.*, hystrix Fr., *G.*, flocculosa Berk., *M.*, *G.*, *R.*, *C.*, cincinnata Fr., *M.*, *G.*, *T.*, Cookei Bres., *R.*, hirsuta (Lasch) Fr., *M.*, *R.*, calamistrata Fr., *M.*, fastigiata (Schaeff.) Fr., *H.*, *T.*, posterula Britz., *G.*
Astrosporina asterospora (Quél.) Rea, *B.*, *T.*, umbrina (Bres.) Rea, *R.*, *H.*, petiginosa (Fr.) Rea, *M.*, *T.*
Hebeloma fastibile Fr., *T.*, mesophaeum Fr., *S.*, *H.*, *T.*, crustuliniforme (Bull.) Fr., *D.*, *T.*, *H.*, elatum (Batsch) Fr., *B.*
Galera hypnorum (Schrank) Fr., *L.*, *T.*, *H.*, tenera (Schaeff.) Fr., *H.*, *A.*, *D.*
Bolbitius titubans (Bull.) Fr., *S.*
Naucoria centunculus Fr., *S.*, escharoides Fr., *S.*, *B.*, *T.*
Tubaria furfuracea (Pers.) W. G. Sm., *L.*, *C.*, pellucida (Bull.) Fr., *T.*
Flammula sapinea Fr., *A.*, *C.*, *B.*, *S.*, carbonaria Fr., *H.*
Cortinarius (Phlegmacium) cyanopus (Secr.) Fr., *C.*, multiformis Fr., *H.*, caerulescens Fr., *T.*, (Myxacium) mucifluus Fr., *H.*, elatior Fr., *C.*, *B.*, *L.*, *T.*, *H.*, vibratilis Fr., *H.*, (Inoloma) bolaris (Pers.) Fr., *T.*, *H.*, (Dermocybe) caninus Fr., *H.*, *T.*, anomalus Fr., *R.*, semisanguineus (Brig.) Maire, *M.*, *T.*, *H.*, cinnamomeus (Wulf.) Fr., *B.*, *T.*, and var. croceus (Schaeff.) Fr., *H.*, (Telamonia) torvus Fr., *C.*, *T.*, hinnuleus (Sow.) Fr., *H.*, *L.*, helvelloides Fr., *R.*, incisus (Pers.) Fr., *R.*, hemitrichus Fr., *T.*, *B.*, *A.*, paleaceus (Weinm.) Fr., *H.*, *A.*, penicillatus (Fr.) Quél., *T.*, (Hydrocybe) saturninus Fr., *H.*, castaneus (Bull.) Fr., *H.*, *B.*, *R.*, leucopus (Bull.) Fr., *H.*, decipiens (Pers.) Fr., *R.*, *T.*
Crepidotus mollis (Schaeff.) Fr., *L.*, calolepis Fr., *C.*, *S.*
Psalliota flavescens Gill., *G.*, *L.*, sylvatica (Schaeff.) Fr., *R.*, sylvicola (Vitt.) Fr., *B.*
Stropharia aeruginosa (Curt.) Fr., *R.*, semiglobata (Batsch) Fr., *M.*, *G.*, *C.*, *D.*, *A.*, *L.*, *H.*, squamosa (Pers.) Fr., *G.*, merdaria Fr., *D.*
Hypholoma sublateritium (Schaeff.) Fr., *S.*, *R.*, capnoides Fr., *T.*, epixanthum Fr., *C.*, *S.*, *T.*, *D.*, *B.*, fasciculare (Huds.) Fr., *G.*, *B.*, *R.*, pyrotrichum (Holmsk.) Fr., *H.*, velutinum (Pers.) Fr., *C.*, *B.*, *L.*, hydrophilum (Bull.) Fr., *C.*, *M.*, *T.*
Psilocybe semilanceata Fr., *S.*, *H.*, *A.*, and var. caerulescens Cooke, *S.*
Psathyra fibrillosa (Pers.) Fr., *L.*, *B.*, *T.*, gossypina (Bull.) Fr., *L.*, *S.*, corrugis (Pers.) Fr., *D.*
Psathyrella gracilis Fr., *R.*, *B.*, atomata Fr., *D.*
Panaeolus campanulatus (Linn.) Fr., *B.*, *C.*, *T.*, *D.*, *A.*, sphinctrinus Fr. *A.*, *C.*, retirugis Fr., *H.*
Coprinus comatus (Fl. Dan.) Fr., *H.*, *L.*, *C.*, atramentarius (Bull.) Fr., *A.*, *C.*, *T.*, micaceus (Bull.) Fr., *B.*, *L.*, *C.*, *S.*, *T.*, lagopus Fr., *L.*, *C.*, *S.*, *H.*, plicatilis (Curt.) Fr., *D.*, *C.*, *H.*, domesticus (Pers.) Fr., *B.*, *C.*, stercorarius Fr., *C.*
Boletus luteus (Linn.) Fr., *L.*, elegans (Schum.) Fr., *A.*, *G.*, *R.*, badius Fr., *R.*, *B.*, *H.*, *T.*, chrysenteron (Bull.) Fr., *H.*, *L.*, *B.*, *M.*, *G.*, *H.*, subtomentosus (Linn.) Fr., *B.*, *L.*, edulis (Bull.) Fr., *R.*, *B.*, *T.*, *H.*, and var. bulbosus (Bull.) Big. & Guill., *T.*, *H.*, calopus Fr., *R.*, *T.*, *H.*, luridus (Schaeff.) Fr., *L.*, *G.*, erythropus (Pers.) Quél., *L.*, *M.*, *H.*, duriusculus Schulz., *C.*, pulverulentus Opat.*, *H.*
Phaeoporus porphyrosporus (Fr.) Bat., *B.*
Polyporus nummularius (Bull.) Quél., *G.*, *S.*, *T.*, varius Fr., *C.*, squamosus (Huds.) Fr., *M.*, *C.*, *S.*, *T.*, sulphureus (Bull.) Fr., *H.*, giganteus (Pers.) Fr., *C.*, *B.*, *R.*, *S.*, *L.*, *T.*, betulinus (Bull.) Fr., *B.*, *S.*, *R.*, dryadeus (Pers.) Fr., *S.*, *T.*, hispidus (Bull.) Fr., *S.*, amorphus Fr., *S.*, *C.*, adiposus B. & Br., *L.*, adustus (Willd.) Fr., *L.*, fragilis Fr., *S.*, caesius (Schrad.) Fr., *S.*, *R.*

* New to Britain.

Fomes annosus Fr., *M.*, *G.*, *S.*, *C.*, *H* (on Ash).
Ganoderma applanatum (Pers.) Pat., *C.*, *S.*, *L.*, *H.*, resinaceum Boud., *S.*
Poria sanguinolenta (A. & S.) Fr., *M.*, *R.*, *S.*
Polystictus versicolor (Linn.) Fr., *C.*, *B.*, *S.*, *H.*, *T.*, *L.*
Irpex obliquus (Schrad.) Fr., *M.*, *C.*, *B.*, *S.*, *T.*, fuscoviolaceus Fr., *B.*
Trametes gibbosa (Pers.) Fr., *L.*, *H.*, mollis (Sommerf.) Fr., *G.*, *C.*, *S.*, *B.*, *T.*, *L.*
Daedalea biennis (Bull.) Quél., *T.*, quercina (Linn.) Fr., *L.*
Merulius corium (Pers.) Fr., *C.*, *T.*, rufus (Pers.) Fr., *S.*
Phlebia merismoides Fr., *T.*
Fistulina hepatica (Huds.) Fr., *L.*
Hydnum repandum (Linn.) Fr., *B.*, *Hazelwood Glen*, and var. rufescens (Pers.) Fr., *G.*, *B.*
Mycoleptodon ochraceum (Pers.) Pat., *M.*, fimbriatum (Pers.) Bourd. & Galz., *S.*
Acia uda (Fr.) Bourd. & Galz., *L.*
Grandinia farinacea (Pers.) Bourd. & Galz., *G.*, *R.*, *S.*, granulosa Fr., *T.*
Odontia bicolor (A. & S.) Bres., *C.*, papillosa (Fr.) Bres., *T.*
Craterellus pusillus Fr., *T.*
Thelephora anthocephala (Bull.) Fr., *C.*, terrestris Fr., *C.*, *T.*
Hypochnus fuscus (Pers.) Fr., *M.*, *R.*, isabellinus Fr., *S.*, roseogriseus Wakef. & Pears., *T.*, fumosus Fr., *R.*, phylacteris (Bull.) Rea, *S.*
Stereum spadiceum Fr., *B.*, *T.*, rugosum Fr., *H.*, hirsutum (Willd.) Fr., *M.*, *C.*, *S.*, *L.*, *T.*, *H.*, purpureum Fr., *C.*, *R.*, *S.*, *H.*, Chailletii (Pers.) Fr., *C.*
Corticium laeve Fr., *H.*, arachnoideum Berk., *R.*, atrovirens Fr., *M.*, Sambuci (Pers.) Fr., *B.*, trigonospermum Bres., *unlocalised*, flavescens (Bon.) Mass., *C.*, confluens Fr., *T.*, confine Bourd. & Galz., *C.*, *T.*, praetermissum (Karst.) Bres., *S.*, lactescens Berk., *M.*, *G.*, albostramineum (Bres.) Bourd. & Galz., *M.*
Peniophora candida Lyman (*Aegerita* stage), *S.*, glebulosa Bres., *S.*, *R.*, pallidula Bres., *L.*, velutina (DC.) Cooke, *M.*, *S.*, setigera (Fr.) Bres., *M.*, pubera (Fr.) Sacc., *C.*, *S.*, *M.*, hydnoides Cooke & Mass., *C.*, *S.*, *L.*, quercina (Pers.) Cooke, *C.*, *S.*, *L.*, incarnata (Pers.) Cooke, *M.*, cinerea (Fr.) Cooke, *M.*
Clavaria cristata (Holmsk.) Fr., *G.*, *C.*, *S.*, *R.*, *T.*, *H.*, cinerea (Bull.) Fr., *C.*, *L.*, *B.*, *R.*, *T.*, *H.*, rugosa (Bull.) Fr. *A.*, *C.*, Kunzei Fr., *H.*, formosa (Pers.) Fr., *G.*, abietina (Pers.) Fr., *R.*, fusiformis (Sow.) Fr., *C.*, *T.*, *H.*, *A.*, *L.*, inaequalis (Muell.) Fr., *T.*, *H.*, *A.*, vermicularis Fr., *C.*
Typhula phacorrhiza (Reich.) Fr., *T.*, incarnata (Lasch) Fr., *T.*
Auricularia auricula-Judae (Linn.) Schroet., *C.*, *L.*
Tremella mesenterica (Retz.) Fr., *C.*, *S.*
Exidia nucleata (Schw.) Rea, *L.*
Sebacina subhyalina Pears., *S.*
Heterochaetella crystallina Bourd., *M.*, *H.*
Tulasnella anceps* Bres. & Syd., on *Pteris*, *H.*
Dacryomyces deliquescens (Bull.) Duby, *C.*, *B.*, *L.*
Calocera viscosa (Pers.) Fr., *H.*, *B.*, cornea (Batsch) Fr., *C.*, *L.*

## GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *M.*, *C.*, *R.*, *T.*
Lycoperdon saccatum (Vahl) Fr., *unlocalised*, perlatum Pers., *B.*, pyriforme (Schaeff.) Pers., *B.*, *G.*, *R.*, *T.*, *H.*
Melanogaster variegatus (Vitt.) Tul., *R.*
Scleroderma aurantium Pers., *M.*, *T.*, verrucosum (Vaill.) Pers., *M.*, *S.*

## UREDINALES

Uromyces flectens Lagerh., on *Trifolium repens*, *L.*, *H.*, Fabae (Pers.) de Bary, on *Faba vulgaris*, *R.*, on *Vicia Cracca*, *Giant's Causeway*, Alchemillae (Pers.) Lév., *G.*, Valerianae (Schum.) Fuck., on *Valeriana officinalis*, *S.*, Scrophulariae (DC.) B. & Br., *T.*, Polygoni (Pers.) Fuck., *R.*, Rumicis (Schum.) Wint., *B.*

* New to Britain.

Puccinia Violae (Schum.) DC., *M.*, *C.*, Epilobii DC., on *Epilobium palustre*, *H.*, Circaeae Pers., *M.*, *L.*, *B.*, Umbilici Guép., *B.*, Aegopodii (Schum.) Mart., *T.*, Saniculae Grev., *G.*, *L.*, *T.*, *R.*, Cirsii Lasch, *L.*, *S.*, Hieracii (Schum.) Mart., *G.*, *S.*, Hypochaeridis Oud., *L.*, expansa Link, *T.*, Taraxaci Plowr., *G.*, *Portrush*, Primulae (DC.) Duby, *M.*, *B.*, *T.*, Veronicae Schroet., on *Veronica montana*, *L.*, *S.*, Glechomatis DC., *C.*, *S.*, *H.*, Menthae Pers., *H.*, annularis (Str.) Schlecht., *T.*, Buxi DC., *S.*, obscura Schroet., *H.*, *R.*, Lolii Niels., *H.*, Poarum Niels. (aecidium), *C.*, *L.*, *T.*, *H.*, Brachypodii Otth, on *Brachypodium sylvaticum*, *R.*

Phragmidium Fragariae (DC.) Wint., *G.*, *H.*, subcorticium (Schrank) Wint., *R.*, *G.*, violaceum (Schultz) Wint., *common everywhere*, Rubi (Pers.) Wint., *B.*, Rubi-Idaei (Pers.) Karst., *B.*

Kuehneola albida (Kuehn.) Magn., *B.*

Coleosporium Campanulae (Pers.) Lév., *Giant's Causeway*, Euphrasiae (Schum.) Wint., *M.*, *H.*, on *Bartsia*, *R.*, *C.*, *Giant's Causeway*, *T.*, Petasitis de Bary, *M.*, Senecionis (Pers.) Fr., *H.*, *L.*, Tussilaginis (Pers.) Kleb., *C.*, *B.*, *L.*, *R.*, *Portrush*, *H.*

Pucciniastrum Circaeae (Schum.) Schroet., *L.*, *B.*, *S.*, Vacciniorum (Link) Diet., *G.*

Milesina Dieteliana Magn., *B.*, Blechni Syd., *T.*, Scolopendrii Syd., *B.*

Melampsora Lini (Pers.) Desm., *H.*

Melampsoridium betulinum (Pers.) Kleb., *C.*, *B.*, *R.*, *T.*

## USTILAGINALES

Ustilago Avenae (Pers.) Jens., *H.*, violacea (Pers.) Wint., *B.*, Scabiosae (Sow.) Wint., *T.*

Sphacelotheca Hydropiperis (Schum.) de Bary, *S.*, *T.*

Entyloma Ranunculi (Bon.) Schroet., *L.*, *T.*, Calendulae (Oud.) de Bary, *G.*, microsporum (Ung.) Schroet., *G.*, *M.*

Urocystis Anemones (Pers.) Schroet., on *Ranunculus repens*, *C.*, *L.*, *H.*

## PLECTASCALES

Elaphomyces variegatus Vitt., *L.*

## PYRENOMYCETES

Sphaerotheca Humuli (DC.) Burr., on *Alchemilla*, *S.*, pannosa (Wallr.) Lév., on Rose, *R.*, on Apple, *Portadown*.

Erysiphe Polygoni DC., on *Circaea lutetiana*, *S.*, on *Heracleum*, *G.*, on garden peas, *R.*, on *Angelica*, *L.*, cichoriacearum DC., on *Plantago major*, *L.*, graminis DC., *Downpatrick*, tortilis (Wallr.) Fr., on *Cornus stolonifera*, *C.*

Uncinula Aceris (DC.) Sacc., *C.*, *B.*, *R.*, *S.*

Nectria cinnabarina (Tode) Fr., *B.*, *L.*, *R.*, *C.*, coccinea (Pers.) Fr., *S.*

Hypomyces rosellus (A. & S.) Tul., *B.*

Epichloe typhina (Pers.) Tul., on *Agrostis*, *Downpatrick*.

Claviceps purpurea (Fr.) Tul., on *Aira caespitosa*, *Phleum pratense*, *Holcus*, *Dactylus*, *Anthoxanthum*, etc., *L.*, *B.*, *T.*, *H.*

Cordyceps ophioglossoides (Ehrh.) Link, on *Elaphomyces variegatus*, *L.*

Naumovia abundans Dobr., *L.*, *H.*, on *Prunella*.

Mycosphaerella carinthiaca Jaap, on *Trifolium pratense*, *H.*, depazeaeformis (Awd.) Lind, on *Oxalis Acetosella*, *G.*

Sphaerulina Taxi (Cooke) Mass., *T.*

Venturia inaequalis Aderh., *C.*, *Portadown*, Rumicis (Desm.) Wint., *H.*

Leptosphaeria acuta (Moug. & Nestl.) Karst., *L.*

Diatrypella quercina (Pers.) Nits., *M.*, *S.*

Diatrype Stigma (Hoffm.) Fr., *C.*, disciformis (Hoffm.) Fr., *C.*, *B.*, *T.*

Ustulina vulgaris Tul., *S.*, *H.*

Hypoxylon coccineum Bull., on *Fagus*, *C.*, *S.*, *L.*, *H.*, fuscum (Pers.) Fr., *G.*, *C.*, *R.*, multiforme Fr., *B.*, rubiginosum (Pers.) Fr., *C.*, semiimmersum Nits., *S.*

Xylaria Hypoxylon (Linn.) Grev., *C.*, *B.*, *R.*, polymorpha (Pers.) Grev., *M.*, *C.*, *S.*, carpophila (Pers.) Fr., *C.*, *B.*, *T.*
Phyllachora graminis (Pers.) Fuck., *L.*, *C.*
Endodothella Junci (Fr.) Theiss. & Syd., *B.*, *H.*
Dothidella Ulmi (Duv.) Fr., *R.*
Rhopographus filicinus (Fr.) Nits., *B.*, *T.*, *H.*

## DISCOMYCETES

Helvella lacunosa Afz., *H.*
Leptopodia elastica (Bull.) Boud., *C.*
Macropodia macropus (Pers.) Fuck., *T.*
Rhizina inflata (Schaeff.) Karst., *B.*
Galactinia succosa (Berk.) Sacc., *C.*, *L.*, *H.*, *R.*, badiofusca Boud., *L.*
Pachyella depressa (Phill.) Boud., *H.*
Otidea onotica (Pers.) Fuck., *C.*, *S.*, *B.*, *R.*, *H.*
Peziza aurantia Pers., *H.*, *L.*
Lachnea hemisphaerica (Wigg.) Gill., *M.*, *L.*
Ciliaria scutellata (Linn.) Quél., *G.*, *C.*, *S.*, *B.*, *L.*, *T.*, *H.*, trechispora (B. & Br.) Boud., *T.*
Taphrina Tosquinetii (West.) P. Magn., *H.*, *S.*, *L.*
Trichoglossum hirsutum (Pers.) Boud., *T.*
Leotia lubrica (Scop.) Pers., *M.*, *G.*, *L.*, *B.*, *R.*, *T.*
Cudoniella acicularis (Bull.) Schroet., *L.*
Calycella citrina (Hedw.) Quél., *S.*, *L.*, *T.*
Coryne sarcoides (Jacq.) Tul., *C.*, *T.*, *L.*, *H.*
Bulgaria inquinans (Pers.) Fr., *R.*
Corynella glabrovirens Boud., *S.*
Orbilia xanthostigma Fr., *C.*, *S.*, *L.*, *H.*
Sclerotinia Curreyana (Berk.) Karst., *L.*
Phialea firma (Pers.) Gill., *H.*
Chlorosplenium aeruginosum (Oeder) de Not., *M.*, *C.*, *S.*, *L.*, *B.*
Dasyscypha virginea (Batsch) Fuck., *H.*
Hyaloscypha hyalina (Pers.) Boud., *S.*
Mollisia cinerea (Batsch) Karst., *M.*, *H.*, *L.*
Heterosphaeria Patella (Tode) Grev., *B.*
Pseudopeziza Trifolii (Biv.-Bern.) Fuck., *H.*, *L.*
Fabraea Ranunculi (Fr.) Karst., *L.*, *Downpatrick.*
Stegia Ilicis Fr., *R.*, *H.*
Rhytisma acerinum (Pers.) Fr., *C.*, *T.*, *M.*, *S.*, *L.*

## PHYCOMYCETES

Synchytrium aureum Schroet., on *Plantago lanceolata*, *C.*
Cystopus candidus (Pers.) de Bary, on *Cardamine hirsuta*, *C.*, on Turnip, *H.*
Phytophthora infestans (Mont.) de Bary, *H.*
Plasmopara nivea (Ung.) Schroet., on *Aegopodium*, *M.*, *C.*, *L.*, *H.*
Peronospora grisea Ung., on *Veronica serpyllifolia*, *B.*, *T.*
Empusa Muscae Cohn, *H.*

## PROTOMYCETACEAE

Protomyces macrosporus Ung., *M.*, *L.*, *T.*, *H.*

## DEUTEROMYCETES

Actinonema Rosae (Lib.) Fr., *M.*, *L.*
Septoria Violae West., *B.*, Polygonorum Desm., on *Polygonum Persicaria*, *H.*, Apii Chester, *H.*, Rubi West., *B.*, Tritici Desm., *B.*
Dilophospora Alopecuri Fr., *B.*
Oidium alphitoides Griff. & Maubl., *M.*, *T.*, *C.*
Trichoderma viride Fr., *T.*

Rhinotrichum Thwaitesii B. & Br., *B.*
Sepedonium chrysospermum (Bull.) Fr., *M., L., T., H.*
Ovularia obliqua (Cooke) Oud., *L.*, sphaeroidea Sacc., on *Lotus uliginosus*, *H.*
Fusoma triseptatum Sacc., *G.*
Ramularia Tulasnei Sacc., on *Fragaria*, *G.*, lactea (Desm.) Sacc., on *Viola*, *M.*, Primulae Thuem., *B., G., S., T.*, calcea (Desm.) Ces., *C., B., S.*, sambucina Sacc., *L., T.*, Valerianae (Speg.) Sacc., on *Valeriana officinalis*, *S.*, Hypochaeridis Magn., *L.*, Taraxaci Karst., *G.*
Hadrotrichum virescens Sacc. & Roum., on *Agrostis*, *H.*
Bispora monilioides Corda, *B., T.*
Polythrincium Trifolii Kze., on *Trifolium repens*, *L.*
Sporocybe Azaleae Peck, *S., T.*
Fusarium udum (Berk.) Wollenw., *S.*

## MYCETOZOA OF THE BELFAST FORAY

By G. LISTER, F.L.S.

The week of the Belfast Fungus Foray was marked by fine weather until the afternoon of the last day. A wide area was covered by excursions which took us over fine and varied scenery to promising looking hunting-grounds but, notwithstanding diligent search by some members of the party, only twenty-five species of Mycetozoa were found. Possibly we were too early in the season and a few weeks later might have brought a richer harvest, but undoubtedly the moist climate of Ireland favours the rapid clothing of fallen logs and moss, and also encourages the growth of a host of wood-lice, slugs and small snails, all of which devour young immature sporangia. On Saturday, September 5th, the day of our arrival, we visited the extensive mixed woods of Mount Stewart on the shores of Strangford Lough; the ground was in many parts carpeted with ivy, and there were not many old logs and stumps remaining. *Fuligo septica* was the only species seen. On Monday, September 7th, we searched in the grounds of Belvoir Park; here the steep woods of oak, ash and beech, with dense undergrowth and marshy hollows, gave varied habitats; twelve species of Mycetozoa were found, including a large but mouldy growth of *Physarum psittacinum* in the interior of a decayed beech stump; this species usually matures in the summer months.

On Tuesday, the 8th, we drove to Shane's Castle on the north shore of Lough Neagh, Co. Antrim. A wide belt of woodland on high ground, consisting of oak, ash, sycamore and some Douglas fir, with plenty of fallen boughs, yielded fifteen species, including three of the genus *Trichia* and four of *Arcyria*.

Wednesday was taken as a day off.

On Thursday, the 10th, we visited the estate of Rademon, Co. Down, and searched for two hours in plantations of larch, spruce and Douglas fir, with some oak; nine species of Mycetozoa were found, among them *Ceratiomyxa fruticulosa* was abundant on decayed stumps;

on a prostrate log some orange plasmodium was seen, and some of it, brought home and kept moist, continued to creep over wet blotting-paper and dead wood for three months after collecting.

Friday, the 11th, we were taken to the Agricultural Research Institute at Hillsborough Park, Co. Down. In mixed wood, bordering a lake, were many old mossy stumps affording abundance of *Fuligo septica* and *Trichia affinis*; fallen wood seemed scarce, a circumstance explained by our seeing a party of boys with wheelbarrows piled high with sticks and boughs that were being carried off for firewood. Seven species of Mycetozoa were seen.

Of our total finds two species, *Badhamia capsulifera* and *Licea pusilla*, appear to be new records for Ireland, and one, *Fuligo muscorum*, is a new record for Ulster; they were all three found in immature condition, and matured some days later after having been kept moist indoors.

In the following list *M.* stands for Mount Stewart; *B.* for Belvoir Park; *S.* for Shane's Castle; *R.* for Rademon; *H.* for Hillsborough Park.

Ceratiomyxa fruticulosa (Muell.) Macbr., *R.*
Badhamia capsulifera (Bull.) Berk., *H.*, on sticks.
Physarum nutans Pers., *B.*, *S.*, *R.*, *H.*, abundant; var. leucophaeum, *B.*, on stump.
P. cinereum Pers., *B.*, a small gathering on moss.
P. psittacinum Ditm., *B.*
Fuligo septica (L.) Gmel., *M.*, *B.*, *S.*, *R.*, *H.*, abundant.
F. muscorum Alb. & Schwein., *S.*, on mossy wood.
Didymium difforme (Pers.) Duby., *B.*, on nettle stalks.
D. squamulosum (Alb. & Schwein.) Fries, *B.*, on moss.
D. nigripes (Link) Fries, Tollymore Park, on dead leaf.
Stemonitis fusca Roth, *B.*, *S.*, *H.*, on dead wood.
Comatricha nigra (Pers.) Schroeter, *B.*, *S.*, *R.*, *H.*, on sticks.
Enerthenema papillatum (Pers.) Rost., *S.*, on oak stick.
Licea pusilla Schrader, *R.*, on dead coniferous wood, clothed with green gelatinous algae, which was brought home on the chance of Mycetozoa developing on it; in four days the *Licea* began to appear, and continued to do so for a week or more.
Tubifera ferruginosa Gmel., Clandeboye and *S.*, where it was found with the young apricot-coloured sporangia forming a large cluster. The usual colour of the immature stage is rose, rarely yellow or white.
Lycogala epidendrum (L.) Fries, *B.*, *S.*, on dead wood.
Trichia affinis de Bary, *S.*, *H.*, on mossy wood.
T. persimilis Karsten, *B.*, *R.*, *H.*
T. scabra Rost., *B.*, in great abundance inside a hollow stump.
T. varia Pers., *S.*
T. decipiens (Pers.) Macbr., *S.*, *R.*, on dead wood.
Arcyria denudata (L.) Wettst., *S.*
A. incarnata Pers., *S.*
A. cinerea (Bull.) Pers., *S.*
A. pomiformis (Leers) Rost., *S.*, on fallen oak bough.

# PRESIDENTIAL ADDRESS

By A. A. PEARSON, F.L.S.

## MODERN WORK ON THE HYMENOMYCETES

One of the penalties of attendance at these forays is that, after a tiring day in the woods, one is expected to listen to a presidential address. I may add that one of the penalties of being president is that one has to prepare an address which shall be, as far as possible, worthy of the occasion. This has perhaps certain advantages. It is good from time to time to halt and make a survey of work done. Unfortunately, the systematist has so little to show as the result of many years' work, that a survey serves only to demonstrate how very little has been accomplished. He may be able to recognise with some degree of accuracy the species he meets with in the country he is most familiar with; he may have brought a little light to bear upon certain groups that were obscure; he may even have added to the species known in his country or discovered species new to science—it all seems so small, so insignificant in comparison with what remains to be done or what has been done by others, that he will hardly dare make his own work the subject of an address to mark a presidential year. I have, therefor, thought it more prudent and at the same time more useful, both for myself and my audience, to make a general survey of the efforts during recent years, in Europe, to clear up the taxonomy of the Hymenomycetes.

The study of the fungi is never likely to be so straightforward as that of flowering plants. It is, perhaps, one of their charms, at least to those who get beyond the initial stages, that one never reaches anything like finality. After twenty year's continuous interest in the Agarics, for instance, one can go into the woods and be certain of meeting something that will require careful examination and probably leave one baffled as to its specific identity. The phanerogams of a district can be learned in a relatively short time; the fungus flora is never exhausted. That may be why there are so few workers in this field of exploration. After a few years' casual interest, most botanists abandon the subject as hopeless. They seek in vain for that sure basis of morphological detail that will enable them to run down a species with certainty. One would expect that at least the more prominent fungus plants would be an easy task for the student, but even here, there is so much that is uncertain, such a lack of agreement among the experts, that one is at times filled with despair. There is only one way to begin the study of the larger fungi. They must be introduced

to us by one who knows them tolerably well; afterwards we recognise them as familiar friends or at least as nodding acquaintances. Doubtless a certain *flair* is required. Given this, together with a proper degree of keenness, and in a few years the budding systematist may be expected to find his way about a Fungus Flora—and then his troubles begin. I need not enlarge on the subject. The difficulties are only too familiar to you.

In recent years, there has been a distinct revival of interest in taxonomic studies, and a glance at the work of mycologists in different countries of Europe may give us some encouragement. The position is certainly very different from what it was before the War of unhappy memory. I propose to consider each country separately.

## France

In the study of the larger fungi, the French are pre-eminent, and more good systematic work has appeared in France than in any other country. This is largely due to the Société Mycologique de France which was founded in 1885. The first president was Quélet. In the generation before the War, Boudier was its most prominent member. Other members of eminence whose work belongs chiefly to the last generation were Patouillard, Peltereau and Dumée. I mention these because their work enters into the period we are considering.

In 1926, mycological science suffered the loss of Patouillard. We learn that he was reconsidering a new edition of his *Essai Taxonomique* enriched with his twenty-five years' further experience. He has left a permanent impress on the classification of the Hymenomycetes. His classification in its general outline has been adopted by modern French mycologists, and some other countries are following their lead.

Peltereau, a prominent and genial figure in the Society, died in 1926. He is best remembered for his wide traditional knowledge of species and his special interest in the Boleti and Russulae.

Dumée, well known among Parisian mycologists, who died in 1930, for some years edited the popular monthly journal, the *Amateur des Champignons*, which has now been discontinued. He contributed to the *Bulletin* and lent considerable support to the Society during the difficult period of the War.

The venerable Bataille is still on the active list. His series of monographs, without being of the detailed and exacting quality that modern students are producing, have been of great service. Many of the subgenera he introduced have been adopted in the more recent classification.

A volume that will be in the hands of mycologists for many years to come is entitled *Hyménomycètes de France*, and was published in 1927 by the French Mycological Society. The authors were H. Bourdot and A. Galzin. For twenty years, instalments had ap-

peared regularly in the *Bulletin*, but the completed work proved to be much more than a reprint of these. Additional species had been found in the interval, and although we may expect many others to be discovered, the authors have given us an authoritative book dealing with all the European groups of the Hymenomycetes except the Boleti and Agarics. This weighty volume is a monument of the labours of two amateurs. Galzin was a retired army veterinary surgeon who, with immense enthusiasm, collected the material which Bourdot, a parish priest of a country village in the centre of France, examined and finally mastered. Altogether, 1032 species are described, including over 150 new species chiefly belonging to the resupinates. The authors pay due tribute to their predecessors, and especially Bresadola. Posterity will, however, give them full credit for bringing into subjection such a mass of material. The Polyporaceae and Thelephoraceae are treated with a thoroughness that was badly needed, and we now have a basic work to refer to for such intractable genera as *Corticium*, *Peniophora*, *Hypochnus* (*Tomentella*), *Poria* and others.

Galzin died in 1925. The Abbé Bourdot (now honorary canon) is still in harness, and, in spite of delicate health which now severely restricts his activities, we may expect from him further contributions to the science he loves.

In modern French mycology, the outstanding personality is René Maire, who has been called "le maître de la mycologie contemporaine." His influence goes far beyond his published work. He is a professor in the University of Algiers, and in recent years his time has been fully occupied with the flowering plants of Algeria, but his early work occupies a place of honour on our shelves, and we all look forward to the day when he will return to his old love and give us that solid taxonomic work he is so well qualified to write. Fortunately, he is still intensely interested in the fungi, and publishes occasional critical notes and describes new species. He also gives help ungrudgingly to the French mycologists. In fact, much of the modern work may be said to derive from the new spirit which René Maire has infused into taxonomic studies, and especially in the study of the Agarics.

One would imagine that the efforts of successive generations of able mycologists would have brought these into critical order, but only those who undertake the task of naming Agarics can understand the difficulties that still beset mycologists who wish to obtain anything like mastery over this large group of fungi. Although they are perhaps the most highly developed among the fungi, their characters cannot be defined with that precision which is so familiar to students of flowering plants. A series of descriptions is apt to leave one bewildered. The microscope has come to our help and added to the morphological characters which make it possible to describe Agarics

in greater detail, but the most important aid to correct determination is a good coloured representation of the plant. These have been sadly lacking. Where they exist, they have been available only to those who possess copies of rare works, and a few of these only are of much assistance. Even our beloved Cooke's *Illustrations* are often a snare and a delusion. We may expect this to be put right in the present generation. Many modern agaricologists combine critical ability with a happy talent for painting. Their efforts are not always of great artistic value. This may be said of the *Icones Selectae Fungorum* of P. Konrad and A. Maublanc, but these authors are rendering a great service to the harassed mycologist by issuing a series of 500 plates which, in many cases, may be said to settle the identity and nomenclature of a number of species which are, or have been, in dispute. They do not claim to do this on their authority alone; other living authorities have been consulted, and notably René Maire. This enterprise is another good example of collaboration, in this case between amateur and professional. Konrad is a Swiss surveyor who devotes his leisure to the collection and critical study of the larger fungi. Maublanc, general secretary of the Société Mycologique de France, brings to the assistance of his colleague a wide acquaintance with the literature as well as confirmatory knowledge and experience of the fungi. Konrad has figured the species from the living plant and is the more active spirit of the two. The drawings are not as naturalistic as we could wish, but the specific features are well brought out and for this reason they fully serve their purpose. Shape and dimension of spores, cystidia, and other microscopic features are added, which may be of use in identification. Up to the present, 350 plates have been issued and the rest will follow.

One of the authors, Maublanc, has also written a useful popular work in two small volumes, which has had a large sale. J. E. Gilbert has made the genus *Amanita* and its allied groups his special study. Like so many good French mycologists, he is a pharmaceutical chemist. His monograph was prepared in 1918 as a thesis for a degree, and since then he has contributed to the *Bulletin* numerous amplifications showing a taste for very thorough, though rather wearisome, discussions of synonymy. He has also written two books, one on fungus spores and the other on the ecology of fungi, in which he has garnered most of the information available on these subjects.

The latest work, representative of a new generation of systematic mycologists, is a monograph of the genus *Inocybe* by Roger Heim, published last July. This is a big book of 429 pages and 35 coloured plates on what some may consider a very small subject. It has been the ambition of many mycologists to deal fully with the Inocybes. This difficult genus has at last found an exponent who has brought to his task qualifications which few possess. Most of us have felt a

hopeless bewilderment in the presence of the many undistinguished members of the *Inocybe* group. Gradually, they have become clearer to us, but at last we can gather these puzzling Agarics knowing that they can be run down with a tolerable certainty.

The first 75 pages of the book are devoted to an essay on the Ochrosporae, proposing a new classification which doubtless will be elaborated later. Then follows an historical account of the genus *Inocybe*. The main part of the work consists of a detailed description and discussion of the species. Heim has adopted a grouping entirely distinct from what we are accustomed to. The generic term *Inocybe* is used throughout. The species are grouped in a series of races (stirpes) which may comprise species with smooth and others with nodulose spores. A key is supplied, however, which serves as a guide to races and species without which the grouping would hardly be practical. It is too early to pass judgment on this important effort, but a first impression is that it is likely to remain for a long time the authoritative work of reference indispensable to every student of the Agarics.

We may briefly refer to researches of a more fundamental kind. R. Kühner in 1926 published the results of his investigations showing that the early development of the hymenium of many Agarics and Boleti takes place on the outside of the primordium or rudimentary fruit body; they are gymnocarpous, not angiocarpous, as was supposed. Similar discoveries had been made a few years earlier in America by Atkinson, Blizzard and Douglas. We are all familiar with the pictures of the mushroom, showing the early appearance of the gills, like two eyes, well inside the fleshy substance. It would appear that in species of *Tricholoma*, *Lactarius*, *Hygrophorus*, *Mycena* and some other genera, also in *Boletus*, the gills or pores are not produced internally, but first grow without any external covering, which, in some cases, may develop later. The Swiss mycologist Fayod had pointed out in 1889 that many groups of Agarics were gymnocarpous, but, for some obscure reason, his work had been ignored, and later authors assumed an endogenous development of the hymenium in all the Agaric groups, except *Cantharellus*. Kühner made other observations, and in view of his tendency to upset the traditional groupings of various genera, we shall look forward to his further taxonomic studies with interest.

There are many others in France who are keen students of the Hymenomycetes, and produce notes of value in the *Bulletin*, such as Barbier, Joachim, Malençon and others too numerous to mention. A special word must be said for the beautiful plates that appear in every number. No wonder France is still the foremost in the study of the groups we are dealing with, where so many are interested in the elucidation of species.

### Switzerland

Switzerland is an active centre for the study of the higher fungi. The Schweizerische Verein für Pilzkunde began, in 1922, the publication of a modest little monthly journal entitled *Schweizerische Zeitschrift für Pilzkunde*. A. Knapp is the editor, and as the paper is also the official organ of the mushroom inspectors of the Swiss markets, it is not surprising that most of the space is devoted to edible and poisonous fungi. The articles are mostly in German, sometimes in French, and recently a few papers in Italian have appeared. The contributors occasionally break into verse in the approved Swiss fashion. In fact, it is a jolly little paper which is gradually settling down to useful work. The Swiss markets during the fungus season are an education in mycology. In Lausanne, for instance, during 1929, there were brought to the Controller 139 species to pass for sale, of which he approved 128.

One of the foremost members of the Swiss Society is Emil Nüesch who has written monographs of *Boletus*, *Lactarius*, *Hygrophorus*, *Tricholoma* and *Clitocybe*. I have seen the last, and it is a detailed study which will be found useful to refer to, especially for the section that includes *brumalis, vibecina* and the other puzzling offspring of the *Clitocybe* brood.

There is a mycological society in Geneva which publishes an unpretentious little *Bulletin* appearing at infrequent intervals. The most prominent personality of the Society is Charles E. Martin, the doyen of Swiss mycologists, whose wide knowledge of species has been of great service to his colleagues. I have already mentioned Konrad, who is more directly associated with the French Society.

Finally, a word should be said of the section dealing with the Basidiomycetes in the well-known book by E. A. Gäumann on the *Comparative Morphology of Fungi*. This work is too technical to appeal to humble amateurs like myself. Gäumann is chiefly concerned with cytological phenomena as a basis for classification, but these cannot be used by the practical systematist, although one attempt has been made in Germany which will be dealt with later.

### Italy

Italian mycology can be summed up in the names of Saccardo and Bresadola. The former did not devote himself in the same degree as the latter to the study of the larger fungi. When the *Flora Italica Cryptogama* was projected, Bresadola was asked to undertake the section dealing with the Hymenomycetes, but could not accept. It was therefore with reluctance that Saccardo took upon himself, with the collaboration of H. Dalla Costa, to be responsible for this part of the

Flora. Bresadola, however, offered to supply him with his notes on the Trentino species, and these have been incorporated in the two large volumes that were published in 1915. Descriptions of species are in Latin, and supplementary notes in Italian. The Friesian classification is adopted. We now have an Italian Flora to work with, if we are so fortunate as to visit Italy and combine the usual studies of its ancient splendours with a little fungus hunting. The thought may occur that these strange growths among the trees are older than the oldest monuments.

Of greater importance to European mycologists is the issue by the Società Botanica Italiana of a series of coloured plates under the title of *Icones Mycologica* by Bresadola, whose influence over two generations has been compared to that of Fries. A few years before his death, which occurred in 1929, by way of celebrating his eightieth birthday, it was arranged to publish a selection of his paintings of fungi, 1000 plates in all. Up to the present 900 plates have been issued, and the Società is to be congratulated on bringing thus far such an expensive series. The plates are well produced, though some are very inadequate representations of the plant. The accompanying descriptions which are in Latin give spore measurements and cystidia also, but not in all cases where they occur. In the later years of his life, Bresadola had been called upon to deal with such masses of exotic fungi, that a critical revision of the European species was hardly possible in his old age. His *Inocybe* plates may be singled out for especial praise, but we are rather startled to find that he endows *Inocybe petiginosa* with a smooth spore. We had thought this common species was quite settled in the minds of systematists, but we have a long way to go before the names of some of the commonest fungi can command general acceptance. Although we must regret that precious space has been wasted by the inclusion of so many species which are well represented in other works, the Bresadola plates are nevertheless a splendid addition to the iconography of the Agarics, and the best monument to the memory of a great mycologist that could have been devised.

## Germany

Before dealing with more specialised studies in Germany, attention may be called to the latest work on General Classification: Engler and Prantl's *Natürlichen Pflanzen Familien*. The second edition of the volume on the Basidiomycetes appeared in 1928. That part dealing with the Hymenomycetes is edited by S. Killerman, and is largely based on the views of Bresadola who collaborated with the editor. The more modern classifications are not adopted as being "etwas fremdartig." According to Bresadola, it is better to adhere to the well-known system of E. Fries and Saccardo, amongst other reasons in order not to make the study of the Agarics unnecessarily difficult

for beginners. The compilers take the whole world in their stride, and have given us an invaluable work of reference.

German mycologists, before the War, did not pay much attention to the larger fungi. The explanation is probably to be found in their not meeting together for field work, thus stimulating an interest in species. Until recent years there was no society to organise fungus forays. A tradition of species is of paramount importance when we are dealing with the fungi, especially the Agarics which possess subtle differences almost impossible to put into words. They elude even the artist's brush. Of course, tradition may go astray. It often does. Each country has its separate tradition. That is why it is so useful for the mycologists of different countries to fraternise. We want international forays, so that a universal tradition may be established and the taxonomy of the Agarics placed on a firmer basis. During the War, the German people began to pay considerable attention to the fungi, and since the Deutsche Gesellschaft für Pilzkunde was formed, a keener interest in what one may call the social and recreational side of mycology has appeared. The organ of the Society, the *Zeitschrift für Pilzkunde*, is published monthly, and deals almost exclusively with the larger fungi. It is well printed and illustrated by reproduction of photographs. The Society has some enthusiastic workers, and a few forays have been organised, which will probably develop into a more regular feature of its activities.

Under the aegis of the Deutsche Gesellschaft für Pilzkunde, F. Kallenbach began, in 1926, the publication of an ambitious but badly needed series of coloured illustrations of Boleti. Each plate contains life-sized reproductions of several specimens, so the sheet is rather large. As the figures are not idealised, but depict the plants as they appear in nature, they should prove of real assistance to the student. The accompanying text is very full; in fact, the work promises to be a good example of German thoroughness, since we are told that, when the Boleti are finished, there is to be a continuation of the enterprise which is designed ultimately to include the whole of the Central European fungus flora. Few of us are likely to live to see the end, since it has taken five years to issue twenty-seven plates covering seventeen species. We all hope that the necessary support will be forthcoming for the effort to continue.

While on the subject of illustrations, the new editions of two very popular German works may be mentioned, both containing coloured plates, most of which are excellent. I refer to the *Führer für Pilzfreunde* by Michael and Schulz, and *Pilze der Heimat* by Gramberg. In the previous editions of both these works, the same mistake occurred of attributing *Amanita pantherina* to *A. spissa*; this has been rectified in the new edition of the Michael and Schulz, beautiful reproductions of both species being given, though many other plates

have doubtful names allotted to them. In Gramberg, the old plate of *A. spissa* is retained, a note being added expressing doubt as to its correct naming. *A. pantherina* is poisonous, but not so dangerous as was thought formerly. It may be mentioned here that recent researches practically confine the species that cause death to *A. phalloides* and its near relatives *A. virosa* and *A. verna*. The terrible character of *A. phalloides* is due to the symptoms not becoming manifest till from eight to forty hours after ingestion, too late for remedial measures to be effective.

Several other species of Hymenomycetes may be termed dangerous such as *Amanita pantherina* and *A. muscaria*, *Lepiota helveola*, *Tricholoma tigrinum*, *Clitocybe rivulosa* and *C. dealbata*, *Entoloma lividum*, *Inocybe Patouillardi* and some other Inocybes, also *Boletus satanas*.

In treating of modern German systematic works, precedence should perhaps have been given to *Die Blätterpilze*. This work on the gilled fungi, published from 1910 to 1915, is by A. Ricken, a parish priest who died in 1921. It is the best of its kind in Europe, since it was largely the result of intensive personal observation and description. Ricken's book has been widely used and frequently quoted. Unfortunately, his names so often conflict with more generally accepted views that we are becoming rather too familiar with the legend *non Ricken* placed after the name of a specific author. Ricken, like most Germans, had worked by himself without the corrective influence of fellow-workers. He also produced a useful handbook *Vade mecum für Pilzfreunde*, with shorter descriptions of the Agarics, including also other groups of the larger fungi.

I have already mentioned Killerman. Between 1922 and 1930 he published four critical lists of Bavarian fungi (*Pilze aus Bayern*) designed with a view to cover the ground worked by the Bavarian mycologists Schaeffer and Britzelmayr. The latter had made so many new species that had not been seen since, that it was desirable to make a special effort to rediscover them. Killerman's twenty years' field work has reduced the number of Britzelmayr's species considerably. In the *Zeitschrift für Pilzkunde*, supplementary criticisms of Britzelmayr's species have been supplied by A. Ade.

An enthusiastic and able student of the Agarics has appeared in the person of Rolf Singer, who published in *Hedwigia* (1926) a monograph of the genus *Russula*. He produces a classification which groups the species round well-known types (*Formenkreise*), a fairly practicable method where the types are universally recognised. The work is the courageous effort of a young mycologist who has made a serious study of a subject which older men approach with fear and trepidation.

A third edition of Lindau's book on *Die höheren Pilze* appeared in 1928. It is practically a new work, reconstructed by E. Ulbrich. His classification is a highly debatable one. The Basidiomycetes are

grouped into two divisions governed by nuclear phenomena which are said to be correlated with the shape of the basidia. Apparent anomalies result from this division. For instance, certain species are withdrawn from the genus *Clavaria* to form a new group which is called Stichoclavariaceae, which have nuclei dividing by longitudinal spindles said to be associated with narrow cylindrical basidia instead of the somewhat broader club-shaped basidia with nuclei dividing by horizontal spindles. He introduces two new genera: *Stichoclavaria* and *Stichoramaria*. In the latter he places our old friends *Clavaria rugosa*, *C. cristata* and *C. cinerea*. It is disconcerting to find these separated from *Clavaria* by some fifty pages. This is rather a remarkable effort for a book intended for beginners. Only about two-thirds of the Agarics described by Ricken are included in the work.

## Austria

The Austro-Hungarian monarchy having been split up into several new national units, we have to consider these separately. Fortunately, any rivalry that may be noted in the efforts to popularise the fungi, to clear up or add to the confusion of species, is not likely to have any disastrous political results. The confusion of tongues, however, is only too apparent.

In Austria the German language is used. We may first mention the work of one who, like so many of those eminent before the War, has gone from this world to another where, let us hope, the problem of species may be considered in a serener atmosphere. The series of critical revisions by von Hoehnel that appeared so regularly in the *Kaiserl. Akademie der Wissenschaften* were an important factor in the modern outlook on the study of the Hymenomycetes. His careful notes on the resupinates were especially helpful. One remembers also a review of the microscopic characters of species of *Mycena*, designed as a preliminary study of this genus, since in many instances he gave contradictory characters for the same species showing how inadequate were the original descriptions. It served, however, to indicate a new approach to this difficult genus, which was being explored on precisely similar lines by Lange in Denmark.

V. Litschauer, who collaborated with von Hoehnel in the resupinates, has continued this part of the work, and publishes descriptions of new species from time to time.

There are mycological societies in Vienna and Graz, and among the well-known mycologists associated with them, one may mention H. Lohwag, K. Keissler and V. Schiffner. No work of outstanding importance has been produced recently.

### Czecho-Slovakia

The mycologists of Czecho-Slovakia (Bohemia) are not widely known. Few will have heard of the late J. Bezdek under whose guidance so many modern Czech mycologists learnt their species. Unfortunately, they write their books in Czech. With the best will in the world, we find it impossible to follow their descriptions. This is much to be regretted, because they are producing valuable work.

We must first call attention to the *Ceské Houby* of Velenovsky, a fungus flora of Czecho-Slovakia published in 1920–2. This author creates 880 new species, mostly Hymenomycetes, all described in the Czech language only. This must be a record in species-making since Friesian times. In the genus *Cortinarius* he has no less than 129 new species to his name, fifty of *Clitocybe*, forty-four of *Inocybe*, thirty-five of *Mycena*, forty-one of *Russula*, sixty-five of *Polyporus* and so on.

Some of the species apparently have been accepted, so the work is not quite so fantastical as one is inclined at first to think. As Latin diagnoses are not given, we can leave to the countrymen of Velenovsky the task of weeding out, and they have already taken in hand the review of some of his species. Pilát accepts one out of eleven species of *Stereum*, and one he places as a subspecies. Cejp gives Latin descriptions of three Velenovsky species belonging to the Hydnaceae. Melzer and Zvara include one of his *Russula*, and place two others as varieties; the remaining thirty-eight are presumably rejected. If the other groups give a similar result, the name of Velenovsky will be well represented in the European flora, but our study will be encumbered with some hundreds of further useless synonyms.

A more favourable impression has been created by a monograph of the genus *Russula* produced in 1927 by Melzer and Zvara, because it appears to be a study of this difficult genus, based on sound knowledge and prolonged research. It has several new features which may tend to the better elucidation of a group of plants which from Fries to the present day has been the despair of mycologists. A work of real authority is therefore badly needed. Unfortunately, the authors have written their monograph in Czech, adding an analytical key in French which is very helpful but leaves the student dependent on the descriptions of species in other books which may not correspond to their own conception of these species. A French translation to include coloured plates has been promised which will be most welcome. The main feature of the work is the use the authors make of chemical reagents. They base their classification on colour reactions which are said to be constant, whereas other characters are inconstant. It is true that even the colour reactions may vary with the age of the specimens, but only in so far as the intensity is concerned. Sulphate

of iron is the most important reagent used, by means of which the Russulae may be divided into

*Indolentes*: flesh without colour reaction;
*Rutilentes*: flesh turning reddish;
*Viridantes*: flesh turning greenish.

The microscopic characters of the pileus are used for subsections. The use of chloral iodine for the examination of the spore has been introduced by the authors, and is now coming into general use.

We have all been rather inclined to make fun of the field mycologist of the future, with his chemical apparatus strapped on his back, but two or three small tubes are sufficient, and will serve to eliminate certain groups and put us on the way to a correct determination. Once we really know a species, such aids are rarely called for.

A. Pilát has written useful monographs of *Stereum*, *Aleurodiscus*, *Cyphella* and other genera, and is now at work on a monograph of the European Polypores. K. Cejp has published a Czech monograph of the Bohemian Hydnaceae. A popular work with excellent coloured figures was produced in 1925 by K. Kavina, but his figure of *Amanita pantherina* is typical *A. spissa*, so the ghost of the early Michael figure now dogs the footsteps of Bohemian mycologists, having been exorcised from its original home. Two monthly publications are devoted to mycology, one to its more popular side, printed on cheap paper and illustrated with numerous photographs and sketches. It is symptomatic of the wide interest in the fungi that a sale can be obtained for a paper of this kind. The other, which is the organ of the Bohemian Mycological Club, bears the title *Mykologia* and is edited by the veteran Velenovsky. Some beautiful coloured plates accompany each number.

### Hungary

The Hungarians write in Magyar, a language of mysterious origin, which few foreigners would attempt to master. The mycologists are keen, and there are popular courses in fungi at Buda-Pest, to teach the people how to recognise edible and poisonous species. Szemere wrote a delightful little book in 1926 with coloured illustrations of common species. A scheme is on foot to publish the work on Hungarian fungi by Stephen Schulzer, the Croatian mycologist who died in 1892, leaving manuscripts of first-class importance on the larger fungi, written in German. An earlier manuscript had served as the basis of Kalchbrenner's work, but the later one is considered of greater importance.

### Scandinavia

Sweden, which to mycologists will always be of irresistible attraction, does not appear to be a centre of great activity nowadays in the study of the larger fungi.

Many of us often think how delightful it would be to wander in the woods and pastures frequented by the venerable Fries, but leisure and opportunity come to those who have little taste for such delights.

The Friesian tradition may still be alive, but we would like to think that the memory of the great master mycologist still inspires his countrymen to continue that intensive study which he found so consoling, even in his old age. Lars Romell, by profession a patent agent in Stockholm, who was the last exponent of the tradition, died in 1927. Like many another, he rushed into print in the early days, but as he became older, he acquired a Hamlet-like diffidence that made impossible that consolidating work we hoped from him.

We are not acquainted with any work from the Norwegians.

Finland still exists on the memory of Karsten, that fine pioneer of the new orientation in taxonomic studies. One thinks of him as one of the ancients, but he died only in 1917 at the age of 83. From 1871 to 1879 he wrote in Latin, but his subsequent writings were in Finnish, we hope to the advantage of his countrymen, but to the loss of a wider circle. Karsten's influence has been considerable, and many of the numerous new genera in his complex system have found acceptance.

## Denmark

In earlier days, Denmark was chiefly known to students of fungi as the home of Holmskiold, who specialised in *Clavaria*, and by citations from the rather indifferent plates in the *Flora Danica*, but we are glad to be able to refer to a modern author, Jacob E. Lange. The series of brochures on the Agarics of Denmark published by him in the *Dansk Botanik Arkiv* have appeared regularly since 1914. Lange is now the principal of the Small-holders' School at Odenske and is a well-known authority on agricultural methods. He has made an intensive study of the Agarics. Nearly forty years ago he began to paint them, and his collection of "portraits" embraces about 1050 species all collected, identified and painted by himself. The booklets he has issued are primarily intended to be used in association with his unpublished drawings, but these are in Denmark, and few can refer to them. The booklets contain authentic measurements of microscopic features which are often missing in the standard works. They have been welcomed everywhere. We cannot, of course, always be sure that his view of a species is the right one, but in critical cases he often gives a full description, and we thus have the means of clearing up many doubtful plants. He started with a monograph of the genus *Mycena*. This is his most important contribution, since he clearly set forth new groupings of this difficult genus, based on the cystidia of the gill edge which had rarely been referred to in previous descriptions of *Mycena* species. As already mentioned, von Hoehnel had published some confusing notes on the same lines, but these were not

known to Lange. The new grouping is a practical one, and should appeal to students who wish to take up a more extended review of the genus. Lange includes only those species which he has met with in Denmark, and much more remains to be done before we have a full range covering all the European species.

Lange followed up his paper on *Mycena*, with a review of *Coprinus* species, also extremely sound and remarkably comprehensive. It would take too long to mention the other papers that followed, all characterised by the same careful work limited always to species examined by the author himself. He departed from his usual methods in dealing with *Russula* where he also gave macroscopic descriptions, but this paper has been overshadowed by monographs of other authors. An invaluable service has been rendered by Lange in devoting his leisure to exact observations of the microscopic features of Agarics.

### Belgium

The Belgian mycologists are a small body and there is little of note to record. In 1922 a popular work was written in French by Beeli and De Keyser, and it was hoped that this would arouse some interest among their compatriots.

### Holland

The Dutch have been more active, and there are several mycologists inspired with the proper keenness. This is as it should be for the country that possesses the Herbarium of Persoon. The Dutch Mycological Society publishes two periodicals, one of a popular kind entitled *Fungus* and another with contributions of a more specialist nature called *Mededeelingen van de Nederlandsche Mycologische Vereeniging*.

The president, J. S. Meulenhoff, and the secretary, W. J. Lütjeharmes, are both interested in the Basidiomycetes. Many papers that have appeared in the *Mededeelingen* are useful contributions to our study: Boedijn on *Inocybe*, Oort on *Mycena* (a delightful little monograph), etc. The latest work of importance is by M. A. Donk, who published last July the first part of a revision of the Hymenomycetae of Holland, excluding the Polyporaceae and the Agaricaceae. He creates a new genus *Botryobasidium* for that section of *Corticium* which Bourdot and Galzin had placed in a separate division Botryodea. These authors had pointed out that several species in this section had secondary spores, and that the basidia and sterigmata bore some resemblance to those of *Tulasnella*. Donk now places his new genus in the Tulasnellaceae.

### Spain

No work of importance on the larger fungi has been attempted in Spain. A meagre list of 300 species was included in the *Flora Española* of Blas Lazaro e Ibaza. Early this year a list of species recorded

for Catalonia was published in a special number of the Catalan botanical journal *Cavanilleria*, and will serve as a basis for future collectors.

### Portugal

The only Portuguese mycologist who has made valuable contributions to our study is Torrend, now a refugee in Paris, his herbarium having been destroyed with most of his notes.

### Poland

There are good field mycologists in Poland, where quantities of fungi are gathered for export. We are told that some twelve million kilogrammes of dried Boleti were shipped chiefly to America.

### Russia

I have not been able to secure any details of activities in that vast tragic expanse we call Russia, but it is hardly likely that the desperate efforts towards some sort of material stability have favoured any interest in species other than those of pathological importance. We note, however, that a survey of the larger fungi in the Caucasus has been started by R. Singer, the Bavarian mycologist, with some measure of support from Leningrad.

### England

Last, but not least, we come to our own country. We cannot boast of a large body of mycologists active in the study of the Hymenomycetes. In other countries, recruits are led to the subject by their interest in edible fungi. In England, the only mushroom admitted to the table is *Psalliota campestris*, and its near relatives. All other species are dubbed toadstools and are deemed to be poisonous. In spite of this, there has always been a fair sprinkling of botanists who have been drawn to this fascinating group, and many have made valuable contributions to its study. Fungus forays which originated in England, have been regular features of many natural history societies, and the tradition of species has thus been kept alive.

A modern book of outstanding importance by a distinguished amateur, Carleton Rea, entitled *British Basidiomycetae*, is known to you all. It has superseded the other English works, and those of us who consult it on these forays and throughout the year, know its high value. Carleton Rea has been guide and counsellor to so many of us, that it is not too much to say that, without him, the tradition of species in this country might have been lost. Knowing his veneration for the great Fries, it was a surprise to discover that he adopted the classification of Patouillard in his book. He must have felt qualms of conscience when he came to the Polypores, for after dividing up the Boleti into different genera in accordance with spore colour, he left

*Polyporus* in its pristine simplicity and preferred to be charged with inconsistency rather than foist upon his faithful followers such names as *Phellinus dryadeus*, *Xanthochrous hispidus*, *Ungulina betulina*, and so on, which will come trippingly off the tongues of our successors.

Rea's book is chiefly valuable for the descriptions of Agarics which he knows well. Spores and cystidia are recorded either from personal observation, or are quoted from continental authors. This is a useful feature of the book, though some of it may require revision as the views of mycologists become more stabilised. Although Rea's work dovetails into the modern ways, he looks back wistfully to days when microscopic characters were considered of minor importance, and in his more trenchant moods he is apt to pour lively scorn on those who give them perhaps undue prominence. The appendices to Rea's work are planned to appear from time to time in the *Transactions* of our Society, where all his previous contributions have been published and of which he was sole editor for twenty years and joint editor for a further thirteen years, a responsibility he has just relinquished.

An important monograph of the genus *Russula* appeared last year, by Richard Crawshay, an Englishman who has collected chiefly in France and Switzerland. He has been fortunate in having the eminent French mycologist Bataille to work with, and has thus acquired the tradition of species under the most favourable auspices. The feature of his book is an intensive study of the spores. Under a high-power immersion lens *Russula* spores are found to have characteristic ornamentations: warts, spines, ridges and reticulations. Crawshay claims that it is possible to recognise a species by spore characters alone. To quote his own words on p. 68: "the determination can usually be made, and sometimes without any other information, from the comparatively simple examination of the spores." I have since learnt that his claims do not go quite so far as this. He would require to have some particulars of colour and taste. Given these, he correctly names the species[1].

Few of us will be willing to devote the time necessary for such observations. The figures of spores reproduced in his book are very accurate, but, except in the case of extremes like *Russula vesca* and *R. foetens*, their distinguishing features are far from apparent. When we have become more familiar with them, we shall probably revise our estimate of the value of these spore figures. Meanwhile, we have Crawshay's key to the species based on field characters alone, and

[1] Recent researches by G. Malençon (*Bull. Soc. Myc. Fr.* XLVII, p. 72) show that the spores of *Russula* and *Lactarius* have a plastic covering which breaks up as the spores expand, thus producing warts and ridges which are too variable to serve as reliable characters to distinguish species. The fact remains that usually the spores produced are stable enough to be characteristic of the species.

this, in conjunction with other work on *Russula* already referred to, should simplify the approach to this difficult genus. Unfortunately, Crawshay's book does not contain his coloured drawings which would have enhanced the value of his work considerably. These have been given to the British Museum (Nat. Hist.) and are delicate examples of mycological art.

Two popular works on the fungi may be mentioned; Swanton's *Fungi and how to know them*, a second edition of which has appeared and can be fully recommended as an introduction for beginners; and Ramsbottom's *Handbook of the larger British fungi*, which contains, in a small space, information of a kind which only the author's intimate knowledge of the subject made possible.

The only other English work of interest to systematists is that of Miss Wakefield who is kept busy at the Kew Herbarium chiefly with exotic fungi, but who has made the resupinate Hymenomycetes her special study. She has also collaborated with Cotton in a useful monograph of the British *Clavaria*.

The Scottish mycologists, once a very active group, are no longer prominent, and there is nothing to report from Ireland.

Before leaving our own country, we must not forget to mention the work of Buller. In his series of books *Researches on Fungi*, he has shown what skill, patience and enthusiasm can do to elucidate the life histories of many Hymenomycetes. Such work is beyond praise. His studies of *Coprinus* place this genus in a group by itself, and his observations on other groups will doubtless have their influence on classification.

And so we come to the end of our review of recent efforts to add to our knowledge of the European Hymenomycetes. Those of us who lack the ability, the time, the taste, the patience, the technique, the extensive literature and iconography necessary to disentangle the complexities of specific nomenclature, are grateful for such work as we have briefly reviewed.

Much remains to be done before we can turn with any assurance to systematic works dealing with some of the genera of Agarics, especially the Ochrosporae. The smaller Cortinarii, for instance, are still in a state of incoherence, and will require a thorough overhauling before we can name them with anything more than a troubled feeling of vagueness and uncertainty. Let us hope this will be put right before long.

In these forays, while pursuing a hobby which takes us into beautiful country, adds to our powers of observation and gives intense pleasure to us all, we are at the same time collaborating in a work of more than local interest. Our subject is peculiar in that we are often dealing with species that occur in all parts of the world. The

substantial uniformity of the fungus flora is indeed very remarkable. The main object of our forays is to foster an accurate tradition of species, and to transmit it faithfully to the next generation. An acquaintance with the work of foreign observers will help to rectify and stabilise this tradition, and with this in view, I have ventured to give you an account of the activities of mycologists in the various countries of Europe.

## REFERENCES


Ade, A. Various papers in *Zeitschrift für Pilzkunde.*

Beeli, M. et de Keyser, M. L. *Les Champignons de Belgique.* Bruxelles (Les Naturalistes Belges) (1922).

Bourdot, H. et Galzin, A. *Hyménomycètes de France.* Paris (Soc. Myc. de Fr.) (1928).

Bresadola, Abbé J. *Iconographia Mycologica.* Milan (Società Botanica Italiana) (1927).

Brinkmann, W. *Die Thelephoreen Westfalens.* Münster (1916).

Buller, A. H. R. *Researches on Fungi.* 4 vols. London (Longmans & Co.) (1909–24).

*Bulletin de la Société Mycologique de France.* Paris.

*Bulletin de la Société Mycologique de Genève.*

Cejp, Karel. *Monografie Hydnacei.* Prague (1928).

Costantin, J. et Dufour, L. *Nouvelle Flore des Champignons.* 4e éd. Paris.

Crawshay, Richard. *The Spore Ornamentation of the Russulas.* London (Baillière, Tindall & Cox) (1930).

Engler-Prantl. *Die Natürlichen Pflanzenfamilien.* 6 Band. Eumycetes (Fungi)—Klasse: Basidiomycetes. Leipzig (1928).

*Flora Italica Cryptogama.* Rocca S. Casciano (1915–16).

*Fungus.* Popular Organ of the Nederlandsche Myc. Ver. Wageningen.

Gäumann, E. *Vergleichende Morphologie der Pilze.* Jena (1926).

Gilbert, Jean-Édouard. *Le Genre Amanita.* Lons-le-Saunier (1918). *La Spore des Champignons supérieurs.* Paris (1927). *La Mycologie sur le Terrain.* Paris (1928).

Gramberg, E. *Die Pilze der Heimat.* 2 vols. Leipzig (1921).

Heim, Roger. *Le genre Inocybe.* Paris (1931).

Kallenbach, F. "Die Röhrlinge (Boletaceae)." *Die Pilze Mitteleuropas,* Band I. Leipzig (1927).

Kavina, Karel. *Atlas Hub.* Prague (1926).

Killerman, Seb. "Pilze aus Bayern." *Denkschriften der Bayer. Bot. Ges. in Regensburg* (1922–31).

Klein, L. und Sydow, P. *Gift und Speisepilze.* Heidelberg (1921).

Konrad, P. et Maublanc, A. *Icones selectae fungorum.* Paris (1924).

Kühner, R. "Contributions à l'étude des Hyménomycètes." *Le Botaniste,* Série XVII. Paris (1926).

Lange, Jakob E. *The Agarics of Denmark.* Copenhagen (H. Hagerup) (1914).

Lindau, G. und Ulbrich, E. *Die höheren Pilze.* Basidiomycetes. Berlin (J. Springer) (1928).

Maublanc, A. *Les Champignons comestibles et vénéneux.* Paris (1926–7).

*Mededeelingen van de Nederl. Myc. Ver.* Wageningen.

Melzer, V. a Zvára, Jar. "Ceské Holubinky." *Russulae Bohemiae.* Prague (V. Komisi Fr. Rivnace) (1927).

Michael, E., Schulz, R. und Hennig, B. *Führer für Pilzfreunde.* Leipzig (1922–7).

*Mykologia.* Edited by J. Velenovsky. Prague.

Nüesch, E. *Die Trichterlinge* (Clitocybe). St Gallen (F. Schwald) (1926).

Pilát, A. *Ceskoslovenskè drevnì houby.* Prague.

RAMSBOTTOM, J. *Handbook of the Larger British Fungi.* London (Brit. Mus., N.H.) (1923).
REA, CARLETON. *British Basidiomycetae.* Cambridge (University Press) (1922).
RICKEN, A. *Die Blätterpilze* (Agaricaceae). 2 vols. Leipzig (T. O. Weigel) (1910–15).
—— *Vade Mecum für Pilzfreunde.* Leipzig (Quelle und Meyer) (1920).
*Schweizerische Zeitschrift für Pilzkunde.* Bern (Bümpliz).
SINGER, ROLF. "Monographie der Gattung Russula." *Hedwigia,* Bd. LXVI. Dresden (1926).
SWANTON, E. W. *Fungi and How to Know Them.* London. 1st ed. (1909).
SZEMERE, LÁSZLO. *Gombáskönyv kezdök részére.* Budapest (1926).
ULRICH, E. *See* LINDAU.
VELENOVSKY, JOS. *Ceské Houby.* Prague (Ceské Botanické Spolecnosti) (1920–2).
*Zeitschrift für Pilzkunde.* Darmstadt.

# APPENDIX II TO *BRITISH BASIDIOMYCETAE*

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(With Coloured Plate)

Five more years have passed since the first Appendix to my work on the *British Basidiomycetae* was published in 1927. During this period many additional species have been found which are not mentioned in that book, including some well known already on the Continent, and others undescribed elsewhere. These additions are incorporated in this Appendix and are mainly due to the investigation of many friends, including Miss C. A. Cooper, Mrs Violet Astley Cooper, E. J. H. Corner, E. Metcalfe Day, Rev. E. A. Elliot, J. S. Hughes, F. A. Mason, A. A. Pearson, A. E. Peck, J. Ramsbottom, Miss Violet Smart, E. W. Swanton, and Miss E. M. Wakefield. My best thanks are due to them for their kind assistance and help.

In the following list I have indicated by an asterisk the position each species should have approximately in the body of the work.

92. Pluteus cervinus (Schaeff.) Fr. Subspecies atromarginatus Konrad. (= *Pluteus umbrosus* Quél.) Konr. & Maubl. Icon. sel. fung. t. 19. *Ater*, black; *marginata*, edged.

Differs from the type in the dark margin of the gills which are formed of balloon-shaped cells filled with a dark brown juice, 40–52 × 20–28 $\mu$. Fir stumps. June—Oct. Not uncommon. (*v.v.*)

121*. Lepiota Olivieri Barla. Barla, Champ. Alp. Marit. t. 9 *bis*, figs. 6–10. M. J. Olivier, the colleague of M. J. Barla.

P. 6–13 cm., *whitish, covered with fibrillose, adpressed, brownish scales, disc brown*, convex, then expanded or slightly depressed; margin *whitish*, undulate, fimbriate. St. 6–15 × 1–2 cm., *white, or whitish*, subcylindrical, sometimes thickened at the apex, *minutely fibrillose*, base *bulbous, sometimes marginately bulbous*. Ring *white*, soft, tomentose, fugacious. Gills *pale wax colour*, free, separated by a narrow, cartilaginous collar, ventricose, crowded. Flesh *white, reddening on exposure to the air, becoming finally brownish*, floccose. Spores white, broadly elliptical, 9–10 × 6–7 $\mu$, 1–2-guttulate, often with a germ-pore. Smell and taste pleasant. Edible. Greenhouses, dead leaves and manure heaps. Sept.—Dec. Uncommon. (*v.v.*)

138*. Lepiota laevigata Lange. Lange, Studies in the Agarics of Denmark, pt. II, Lepiota, t. 1, fig. *a*, as *Lepiota gracilis* Quél.
*Laevigata*, made smooth.

P. 1–3 cm., *fulvous-ochraceous or gilvous, margin paler*, convex, then expanded, subumbonate, fibrillosely floccose. St. 2·5–5 cm. × 2–3 mm. *concolorous or paler*, equal, fibrillose or floccosely squamulose. Ring *white*, fugacious. Gills *white, with a slight gilvous tint*, becoming discoloured when bruised, free, rounded behind, rather crowded. Flesh *white, often tinged reddish in the stem*. Spores white, oblong-elliptical or fusiform, sometimes with a spine-like, lateral appendage, 13–14 (–15) × 4–5 $\mu$, contents granular; basidia broadly elliptical, 20–24 × 8–9 $\mu$, with 4-sterigmata 4–5 $\mu$ long. Marginal cells hyaline, clavate, 25–28 × 7–8 $\mu$. Smell slight, sweetish. Taste pleasant. Bare soil in woods and roadsides. Sept.—Oct. Not uncommon. (*v.v.*)

139*. Lepiota brunneo-incarnata Chodat & Martin. (= *Lepiota helveola* Bres. sec. Barla; *Lepiota Barlae* Pat.; *Lepiota Barlaeana* Pat.) Konr. & Maubl. Icon. sel. fung. t. 13.
*Brunneus*, brown; *incarnata*, flesh colour.

P. 2–4·5 cm., *pale flesh colour, covered with numerous, concentric, more or less fugacious, adpressed reddish-lilac-vinous squamules, then becoming brownish, disc darker*, somewhat fleshy, hemispherical, campanulato-convex, or conically campanulate, then expanded and slightly umbonate; margin thin, incurved, slightly exceeding the gills. St. 3–4·5 cm. × 4–10 mm., *whitish or flesh colour*, equal, apex mealy, *covered in the basal two-thirds with the fibrillose squamulose veil forming concentric squamules coloured like those of the p.*, denser at the base, forming at the apex a narrow, sinuous, *whitish*, fugacious ring, finally the squamules disappear leaving the st. floccose. Gills *white, finally tinged near the edge with dirty, vinous purple*, very free, distant, fairly broad, ventricose; edge floccose. Flesh *white*, becoming more or less pale lilac-flesh colour at the periphery of the st. and under the epidermis of the p., soft. Spores white, elliptic-ovoid, pruniform, 8–10 × 5–6 $\mu$ in normal forms, 4–6 × 2·5–3 $\mu$ in microspore forms. Marginal cells hyaline, clavate, 30–42 × 8–12 $\mu$. Smell and taste slight, somewhat bitter. Pastures, hedgesides and woods. June—Oct. Uncommon. (*v.v.*)

144*. Lepiota lilacea Bres. Bres. Fung. Trid. t. 106, fig. 1; Iconog. Mycol. t. 39, fig. 1. *Lilacea*, lilac-coloured.

P. 2–3·5 cm., *purplish lilac, becoming decoloured*, somewhat fleshy, campanulato-convex, then expanded and depressed, sometimes umbonate, fibrillose, *becoming broken up into minute, somewhat fuscous squamules*. St. 2·5–3·5 cm. × 3–4 mm., *whitish, becoming tinged with flesh or lilac colour*, equal, fibrillose, becoming smooth. Ring *white above, fuscous below*, membranaceous, distant, persistent or fugacious.

Gills *white*, free, ventricose, rounded behind, somewhat crowded; margin fimbriate under a lens. Flesh *white, often tinged reddish at the sides of the st.* Spores white, elliptical with an oblique basal apiculus, 5–6 × 3–4 $\mu$ ("4–5 × 2–2·5 $\mu$" Bres.), 1-guttulate; basidia clavate, 20–27 × 6–9 $\mu$. Marginal cells like sterile basidia. Woods and pastures. July—Oct. Not uncommon. (*v.v.*)

192. Psaliota campestris (Linn.) Fr. var. squamulosa Rea.
*Squamulosa*, squamulose.

Differs from the type in the *p. being covered with fuscous or greyish, adpressed squamules.* Pastures and hillsides. June—Oct. Not uncommon. (*v.v.*)

192*. Psaliota flocculosa Rea. *v.* Pl. *Flocculosa*, woolly.

*Entirely snow white.* P. 5–7 cm., fleshy, campanulate, then convexo-expanded, *densely covered with concolorous, imbricate, floccose scales*; margin exceeding the gills, appendiculate with the partial veil. St. 6–8 × 1·5–2 cm., enlarged upwards, attenuated at the base, solid, silky, slightly squamulose below the ring. Ring membranaceous, *narrow*, subdistant. Gills *white, then purple*, free, narrow, 4–5 mm. broad, somewhat crowded. Flesh *white, unchangeable*, thick, firm, thin at the margin, exceeding the gills. Spores purple, broadly elliptical, 7–9 × 5–6 $\mu$, 1-guttulate, with an apical germ-pore. Smell none. Taste pleasant. Pastures under birches. Oct. Rare. (*v.v.*)

197*. Psaliota impudica Rea. *Impudica*, unblushing.

P. 5–10 cm., *rufous fuscous, or brownish*, oval, then campanulate and flattened, *covered with darker, adpressed, fibrillose scales*, disc often remaining continuous; margin at first incurved, exceeding the gills. St. 6–11 × 1–2 cm., *white*, equal, often more or less bulbous at the base, silky. Ring *white*, persistent, superior, membranaceous. Gills *white, then rosy flesh colour, and finally purple-umber*, free, 4–8 mm. broad, crowded. Flesh *persistently white*, firm. Spores purple-brown in the mass, elliptical, with a sub-basal apiculus, 4–5 × 3 $\mu$, with a large central gutta. Smell and taste pleasant. Edible. Woods and pastures. July—Nov. Uncommon. (*v.v.*)

199*. Psaliota pallens (Lange) Rea. (= *Psaliota rubella* (Gillet) Lange forma *pallens* Lange.) *Pallens*, pale.

P. 4–5 cm., *almost pure white, becoming purplish with age, and stained with yellow when touched or bruised*, fleshy, convex, then expanded, minutely silky-fibrillose. St. 5–6 cm. × 8–12 mm., *white, becoming stained with yellow when touched*, somewhat bulbous at the base, slightly enlarged at the apex, fibrillosely floccose below the ring. Ring *white*, thin, fugacious. Gills *white, then flesh colour and finally brownish purple*, free, slightly ventricose, crowded. Flesh *white, becoming stained with*

*yellow in places*, firm. Spores reddish purple, oval, apiculate at base, 4–5·5 × 3–3·5 μ, 1-guttulate. Marginal cells clavate. Woods, pastures and under trees. July—Oct. Uncommon. (*v.v.*)

202*. Psaliota sanguinaria (Karst.) Lange. *Sanguinaria*, bloody.

P. 5–8 cm., *pale fuscous, or pale fawn colour*, fleshy, campanulate, then expanded, obtuse, *fibrillose, soon becoming broken up into adpressed, imbricate, sometimes darker scales*, disc often remaining continuous. St. 7–10 × 1–1·5 cm., *white, becoming yellowish when touched in a young state, then darker and finally fuscous*, equal, often bulbous at the base, silky flocculose, then *almost glabrous*. Ring *white, becoming dingy, especially on the areolately scaly underside*, superior, pendulous, persistent, *margin thickened*, often radiately striate. Gills *white, then rosy umber, edge often reddish, becoming blood-red when wounded*, free, 7–8 mm. broad, crowded. Flesh *pale, becoming immediately blood-red when broken, thin*, firm. Spores deep purple-brown in mass, elliptical, 5–7 × 3–4 μ, 1-guttulate. Marginal cells clavate. Smell and taste slight, pleasant. Edible. Woods and downs. Sept.—Oct. Uncommon. (*v.v.*)

232*. Amanita Eliae Quél. Boud. Icon. Mycol. 1, t. 5.
Elias Fries, the eminent Swedish mycologist.

P. 4–13 cm., *tawny, or greyish ochre with a tinge of flesh colour*, campanulate, then expanded, umbonate or gibbous, slightly viscid, smooth, satiny, *covered with a few fugacious patches of the white, then yellowish volva*; margin striate. St. 10–13 × 1–1·5 cm., *white, or slightly tawny*, equal, slightly enlarged at the apex, sub-bulbose at base, white squamulose below the ring. Ring *white*, distant, reflexed, often torn at the margin. Volva *white, or greyish, peronate*, fragile. Gills *white*, free, broader in front. Flesh white, thin at the margin. Spores white, ovoid, 12–14 × 7–9 μ. Woods and open downs with trees. Aug.—Oct. Uncommon. (*v.v.*)

328*. Stropharia psathyroides Lange. Lange, Studies in the Agarics of Denmark, pt. v, t. 1, fig. *f*.
*Psathyra*, the genus *Psathyra*; εἶδος, like.

P. 1·5–3 cm., *date-brown, or subfuscous when moist, pallid or subochraceous when dry*, submembranaceous, subconical, then expanded, slightly striate. St. 6–8 cm. × 2–3 mm., *whitish*, equal, slightly thickened at the base, *smooth*. Ring *white*, membranaceous, narrow. Gills *white, or pallid, becoming fuscous*, adnexed, ventricose, somewhat crowded; *edge whitish*. Flesh *concolorous*, thick at the disc, thin at the margin. Spores fuscous in the mass, dark brown under the microscope, phaseoliform, 8–9 × 4–5 μ; "basidia 4-spored. Cystidia bottle-shaped" Lange. Amongst *Sphagnum* and *Polytrichum* under birch. Sept.—Oct. Rare. (*v.v.*)

396*. Cortinarius (Inoloma) humicola (Quél.) R. Maire. (= *Dryophila humicola* Quél.) Bull. Soc. Myc. Fr. xxvii (1911), t. 15, figs. 4, 5.
*Humus*, soil; *colo*, I inhabit.

P. 1–5 cm., *ochraceous yellow, covered with tawny ferruginous, fibrillose, adpressed scales*, fleshy, firm, *conico-campanulate, pointed*, then slightly expanded and more or less umbonate; margin *concolorous*, incurved, then straight, subfimbriate. St. 3–5 cm. × 6–10 mm., *ochraceous, tinged with tawny ferruginous, base entirely tawny ferruginous, covered with tawny ferruginous, fibrillose, recurved scales*, equal, attenuated at the base. Cortina *whitish*, then *tawny ferruginous*. Gills *whitish, then pale brown and finally brown ferruginous*, broadly adnate, slightly sinuate, attenuated in front, straight, somewhat distant, 5–6 mm. wide, thin; edge *white for a long time*. Flesh *whitish, tawny ferruginous in the st.*, very thick at the disc, firm, thin at the margin. Spores brown ferruginous in the mass, elliptical, 8–9 × 5–6 $\mu$ ("9–12 × 4·5–7 $\mu$" sec. Maire), apiculate at the base, generally 1-guttulate, minutely verrucose. Smell faint, pleasant, like that of *Pholiota squarrosa*. Taste mild. Amongst dead leaves in deciduous woods. Sept.—Oct. Uncommon, sometimes locally abundant. (*v.v.*)

541. Inocybe Queletii R. Maire & Konr. (= *Inocybe rimosa* Quél., Massee, non Fr. Rick. &) Konr. & Maubl. Icon. sel. fung. t. 98.
Lucien Quélet, the eminent French mycologist.

P. 2·5–6 cm., *yellowish, disc rather tawny*, fleshy, campanulato-convex, then expanded and gibbous, *fibrillose, longitudinally cracked*, disc often entire; margin thin, at first appendiculate with the fugacious, white veil. St. 4–7 cm. × 5–15 mm., *white, then pale yellowish*, firm, cylindrical, often curved, base thickened, often bulbous, fibrillose, apex white-mealy. Gills *pale greyish white, then yellow-clay colour and finally fuscous ferruginous*, deeply emarginate, uncinato-free, slightly ventricose, attenuated behind, rather broad; edge *pale*, floccose, *denticulate*. Flesh *white*, firm. Spores brownish ochraceous in the mass, pale under the microscope, pruniform, ovoid or subreniform, unequal, 9–13 (–14) × 5–7 $\mu$. Marginal cells sparse, hyaline, clavate, 30–55 × 10–15 $\mu$. Cystidia abundant on gill surface and edge, *hyaline*, fusiform, ventricose, 50–75 × 15–20 (–25) $\mu$, apex muriculate, often pale ochraceous, thick-walled. Smell faint, spermatic. Taste pleasant. Fir woods and under conifers. May—Sept. Common. (*v.v.*)

541**. Inocybe posterula (Britz.) sec. Lange.
*Posterula*, a small back door.

P. 3–5 cm., *pale ochraceous, disc darker, subfulvous*, fleshy, campanulate, then expanded, umbonate, almost smooth, *then somewhat fibrillose and longitudinally cracked*. St. 4–6 cm. × 4–7 mm. *white, becoming brownish with age* especially at the apex, equal, base clavate or

sub-bulbous, fibrillose, silky. Gills *whitish, then pale yellowish cinnamon*, adnate, attenuated behind, rather crowded. Flesh *white*, thin. Spores fuscous ferruginous in the mass, broadly elliptical or oval, 7–8 × 4·5–5 μ, 1-guttulate. Cystidia on both gill face and edge, hyaline, narrowly fusiform, 50–55 × 10–12 μ, apex muriculate. Smell spermatic or none. Coniferous woods. July—Oct. Not uncommon. (*v.v.*)

576*. Inocybe Patouillardii Bres. (= *Inocybe Trinii* (Weinm.) Bres. var. *rubescens* Pat. *Inocybe repanda* Secrétan, Roll.) Konr. & Maubl. Icon. sel. fung. t. 86.
N. Patouillard, the eminent French mycologist.

P. 3–7 cm., *white, then yellowish white-flesh colour, becoming reddish, and finally becoming brownish vermillion*, fleshy, conico-campanulate, then expanded, umbonate, lobed, dry, adpressedly silky fibrillose, then rimose; margin inrolled at first, then expanded, thin. St. 4–10 × 1–2 cm., *white, then tinged reddish*, equal, base slightly bulbous, apex pruinose. Gills *white, then brownish olive, becoming reddish especially on the edge near the margin of the p.*, adnate, emarginate, almost free, narrow, becoming wider with age, crowded, edge white floccose. Flesh *white*, firm, fibrous. Spores ferruginous, elliptical, or subreniform, 10–15 × 6–8 μ. Marginal cells cylindric-clavate, 55–75 × 10–12 μ. Smell earthy. Taste mild. Poisonous. Parks, promenades, mixed woods, often under beeches and limes. May—Sept. Not uncommon. (*v.v.*)

583*. Inocybe maculata Boud. Bull. Soc. Bot. Fr. xxxii (1886), t. 9, fig. 2. *v.* Pl. *Maculata*, spotted.

P. 2–8 cm., *tawny fuliginous, or brown, covered with white, silky, superficial, fugacious squamules*, campanulate, then expanded, umbonate, fibrillosely rimose. St. 3–8 cm. × 5–10 mm., *concolorous, paler than the p.*, equal, base somewhat thickened, subfibrillose, apex mealy. Gills *tawny olivaceous*, sinuate or free, 4–7 mm. wide, crowded, *edge paler*. Spores brown in the mass, ochraceous under the microscope, elliptic-oblong, 8–11 × 5–7 μ, 1–multi-guttulate; basidia clavate, 25–35 × 7–10 μ. Marginal cells hyaline, oblong or clavate, 30–40 × 15–18 μ, thick-walled. Woods. July—Oct. Rare. (*v.v.*)

703*. Tricholoma evenosum (Sacc.) Rea. (= *Tricholoma cnista* Quél., Bres., Rick.; *Tricholoma cnista* Fr. subsp. *evenosum* Sacc.; *Melanoleuca evenosa* (Sacc.) Konr & Maubl.) Konr. & Maubl. Icon. sel. fung. t. 272. *Evenosa*, unveined.

P. 5–10 cm., *whitish, disc straw or tan colour*, fleshy, convex or gibbous, then expanded and obtusely umbonate, smooth, somewhat moist, shining when dry, *the epidermis breaking up in an areolate manner*; margin involute. St. 5–6 cm. × 8–10 mm., *white*, equal or sub-

bulbous, fibrillose, *apex pruinosely mealy*. Gills *white*, sinuato-uncinate behind, easily separating from the hymenophore, crowded. Flesh *white, sometimes becoming reddish when broken, then somewhat greyish fuscous*, soft, fibrous in the stem. Spores *white*, minutely rough, elliptical, 7–9 × 4–5 μ; basidia clavate, 30 × 6–7 μ. Cystidia hyaline, flask- or bottle-shaped, shaggy at the apex, 30–65 × 10–14 μ. Smell of new meal. Taste mild. Edible. Woods and pastures. May—Oct. Uncommon. (*v.v.*)

728*. **Entoloma nitidum** Quél. *Nitidum*, shining.

P. 2–5 cm., *dark violet-blue*, somewhat fleshy, campanulate, then expanded, fibrillose, *silky, shining*; *margin often exceeding the gills*. St. 3–5 cm. × 3–10 mm., *concolorous*, equal, or constricted above and below, often twisted, fibrillose, base white floccose. Gills *white, then flesh colour*, sinuato-adnexed, soon free, ventricose, 4–5 mm. wide, subdistant. Flesh *white, bluish under the cuticle of the p. and st.* Spores pink, angular, globose, 7–8 μ, with a large central gutta. Pine woods and under conifers. Sept.—Oct. Rare. (*v.v.*)

852*. **Clitocybe paropsis** Fr. Bres. Iconog. Mycol. t. 157.
παροψίς, a dainty side-dish.

P. 3–5 cm., *dark crust colour*, fleshy, convex, *umbilicate*, then subinfundibuliform, *subtomentose or subsquamulose*, becoming smooth; margin membranaceous, *often briefly grooved*. St. 3–5 cm. × 4–6 mm., *subconcolorous*, equal, *very fibrillose or subsquamulose*. Gills *whitish, then wash-leather colour*, deeply decurrent, crowded. Flesh *whitish*, firm. Spores white, oblong, 6–9 (–11) × 4–4·5 (–5·5) μ. Smell and taste none. Edible. Beech woods. Sept.—Oct. Uncommon. (*v.v.*)

860*. **Clitocybe paradoxa** Cost. & Duf. (= *Lepista paradoxa* (Cost. & Duf.) R. Maire; *Leucopaxillus paradoxus* (Cost. & Duf.) Boursier.) Konr. & Maubl. Icon. sel. fung. t. 301, as *Lepista paradoxa* (Cost. & Duf.) R. Maire. *v.* Pl. παράδοξος, strange.

P. 4–8 cm., *whitish, becoming tinged with ochraceous cream colour, very fleshy*, convex, then flattened at the disc, dry, glabrous, dull, *more or less areolately cracked*, the areolae deeper in colour, pellicle adnate; margin *white, involute, pruinosely subtomentose*, often slightly grooved. St. 4–8 × 1–2 cm., *white, becoming tinged with yellow*, equal, bulbous at the floccose base, firm, dry, smooth, or minutely fibrillose or squamulose. Gills *white, with a tinge of rose colour at first or with a greyish tinge later*, decurrent, *easily separable from the hymenophore*, attenuated at both ends, rather narrow, 4–5 mm. broad, curved, crowded, *more or less anastomosing in a network at the apex of the st.*, often connate in twos at the base, sometimes forked. Flesh *white, thick*, firm. Spores white in the mass, hyaline, elliptical or obovoid with a sublateral basal

apiculus, 7–8 × 4–5 μ, *verrucose, turning blue with iodine*, with a large central gutta; basidia clavate, 35–40 × 7–8 μ, with 4-sterigmata, 5–6 μ long. Cystidia none. Smell *strong, like Tricholoma lascivum*. Taste pleasant. Under firs and oaks in woods and grassy places. Sept.—Nov. Rare. (*v.v.*)

912. Hygrophorus agathosmus Fr. forma aureo-floccosus Bres. Bres. Iconog. Mycol. t. 320. *Aureus*, golden; *floccosus*, woolly.

Differs from the type in having *golden yellow squamules at the apex of the stem*, which are formed by caespitose, connate, clavate cells filled with a golden yellow juice. Coniferous woods. Sept. Uncommon. (*v.v.*)

924. Hygrophorus niveus (Scop.) Fr. var. fuscescens Bres. Bres. Iconog. Mycol. t. 330. *Fuscescens*, becoming fuscous.

Differs from the type in its somewhat fuscous colour and larger spores 9–12 × 6–7 μ. Pastures. Sept.—Nov. Not uncommon. (*v.v.*)

928*. Hygrophorus streptopus Fr. Bres. Fung. Trid. t. 164 and Iconog. Mycol. t. 334. στρεπτός, twisted; πούς, foot.

P. 3–5 cm., *whitish cinereous, disc fuscous hazel*, somewhat fleshy, campanulate, then expanded, moist, glabrous; margin *often lobed*. St. 4·5–6 cm. × 6–7 mm., *white*, attenuated downwards, *often curved, undulate and twisted*, stuffed, then hollow. Gills *white*, sinuato-adnate, narrow, 4–5 mm. wide, somewhat crowded, veined at the base. Flesh *white*, sometimes with a rosy tinge at the base when broken. Spores white, obovate-oblong, 7–8 × 4–4·5 μ. Smell and taste none. Gregarious. Pastures and woods. Sept.—Oct. Uncommon. (*v.v.*)

953*. Hygrophorus tristis (Pers.) Bres. Bres. Iconog. Mycol. t. 349. *Tristis*, sad.

P. 2–7 cm., *yellow, or spotted with orange-scarlet, becoming black*, submembranaceous, conico-campanulate, then expanded, viscid, smooth; margin lobed. St. 7–9 cm. × 5–8 mm., *yellow, sometimes tinged with scarlet, becoming black*, cylindrical, *fragile*, fibrillose. Gills *whitish, becoming fuliginous yellow or pallid olivaceous*, rounded behind, free, subdistant. Flesh *whitish yellow, becoming black when broken or dried*. Spores white, elliptical, 9–12 × 6–7 μ. Pastures, heaths, sea cliffs and woods. July—Oct. Common. (*v.v.*)

953**. Hygrophorus citrino-virens Lange. (? = *Hygrophorus croceus* (Bull.) Bres. t. 348.) Lange, Studies in the Agarics of Denmark, pt. v, t. 1, fig. *g*. *Citrinus*, lemon-yellow; *virens*, becoming green.

P. 1–4 cm., *sulphur-yellow, becoming tinged with green*, acutely conico-campanulate, 2–4 cm. high, then expanded, dry, innately fibrillose, *never becoming black*; margin lobed. St. 5–7 cm. × 5–10 mm., *pale lemon-*

*yellow, tinged with green*, base white, fibrillosely striate, equal, often compressed. Gills *white*, attenuated behind, narrow, 2–4 mm. wide ("deeply emarginate" Lange), thick, distant. Flesh *greenish yellow, never becoming black*, thin except at the acutely conical disc. Spores white, obovate or obtusely oval, 8–10 × 5–6 $\mu$, contents granular. Pastures and heaths. Oct. Rare. (*v.v.*)

1006*. **Flammula limulata** Fr. Bres. Iconog. Mycol. t. 785. *v.* Pl. *Limula*, a small file.

P. 2–5 cm., *tawny ferruginous*, somewhat fleshy, *campanulato-convex, then expanded*, irregular, obtuse, disc sometimes depressed, *covered with innate, floccose papillae or warts*, consisting of tawny, septate hairs, 95–110 × 10–13 $\mu$; margin *at first often golden yellow*. St. 2–5 cm. × 2–6 mm., *brownish, becoming fuscous*, equal, *fibrillose*, subvillose. Cortina *white*, fibrillose, fugacious. Gills *golden yellow, then cinnamon*, adnate, ventricose, 5–6 mm. broad, crowded. Flesh *reddish*, thick at the disc, thin elsewhere. Spores ferruginous, elliptical, depressed on one side, 7–8 × 4–4·5 $\mu$, 1-guttulate. Taste slightly bitter. Caespitose. Pine stumps and sawdust heaps. July—Oct. Rare. (*v.v.*)

1026*. **Collybia capniocephala** (Bull.) Bres. (= *Hebeloma capniocephalum* (Bull.) Fr. sub. *Agarico.*) Bres. Iconog. Mycol. t. 199. *καπνός*, smoke; *κεφαλή*, head.

P. 4–7 cm., *fuscous chestnut, becoming gilvous, at length covered with black spots*, fleshy, convex, then plane, smooth, glabrous; margin often undulately lobed. St. 3–6 cm. × 8–14 mm., *pallid above, concolorous below, spotted with black when touched*, subequal, fibrillose, subcartilaginous, solid. Gills *whitish grey, then alutaceous, spotted with black when touched*, sinuato-adnate. Flesh *whitish, becoming black when broken*. Smell somewhat unpleasant. Taste mild. Spores white, obovate, 4–5 × 2–3 $\mu$. Fir woods. June—Oct. Very rare. (*v.v.*)

1083*. **Leptonia acuta** Rea. *v.* Pl. *Acuta*, pointed.

P. 2–2·5 cm., *greyish fuscous*, somewhat fleshy, conico-campanulate, 1·5 cm. high, *acutely umbonate*, innately fibrillose; margin incurved. St. 4 cm. × 3–4 mm., *white*, equal, smooth. Gills *white, then flesh colour*, adnexed, attenuated in front, ventricose behind, somewhat crowded. Flesh *white, fuscous under the cuticle of the p.*, thick at the disc, thin at the margin. Spores pink, 6-angled, 9–10 × 7–8 $\mu$, with a large central gutta. Smell slight, of new meal. Amongst moss and heather under pines. Oct. Rare. (*v.v.*)

1272*. **Mycena osmundicola** Lange. Lange, Studies in the Agarics of Denmark, pt. 1, t. 1, fig. *j*. *Osmunda*, the Royal Fern; *colo*, I inhabit.

P. 2–7 mm., *pale greyish, then white*, membranaceous, conical, then

somewhat expanded, grooved with distinct striae almost to the disc, *densely covered with snow white meal* consisting of globose, warted cells, 35–40 $\mu$ in diam. St. 2–3 cm. × 1 mm., *white*, attenuated upwards, *minutely pilose*. Gills *white*, adnate, rather narrow, subdistant. Flesh *white*, very thin. Spores white, ovate-ellipsoid, 7·5–9 × 4–4·5 $\mu$; basidia 4-spored. Cystidia hyaline, oblong or oval, minutely warted. On *Osmunda* fibre in orchid houses. Jan.—Dec. Common.

1382*. **Omphalia tricolor** (A. & S.) Fr. (= *Omphalia sciopus* Quél. sec. Bres.) Bres. Iconog. Mycol. t. 265, fig. 1.

*Tres*, three; *color*, colour.

P. 6–10 mm., *at first tinged with ochraceous flesh colour, then whitish*, membranaceous, convex, then depressed and umbilicate, rugulose, pruinose under a lens. St. 1·5–2·5 cm. × 1–2 mm., *whitish or pinkish above, fuscous fuliginous or dark blue downwards*, equal, *pruinose*. Gills *white, then somewhat pink or yellow*, decurrent, thick, distant. Flesh *concolorous*, thick at the disc. Spores white, oblong, apiculate at the base, 10–13 × 4–5 $\mu$. Cystidia hyaline, fusiform, apex pointed, 80–100 × 15 $\mu$. Amongst grass. March—Oct. Uncommon. (*v.v.*)

1507. **R. lepida** Fr. var. **Aurora** (Krombh.) Bres. Bres. Fung. Trid. t. 205, and Iconog. Mycol. t. 414.

*Aurora*, the goddess of dawn.

Differs from the type in the *whitish yellow p. becoming tinged with isabelline flesh colour or pink, the unchanged colour of the disc, and its larger size*. Deciduous woods. Aug.—Oct. Uncommon. (*v.v.*)

var. **amara** R. Maire. *Amara*, bitter.

Differs from the type in the *unpleasant bitter taste of the flesh* and *especially of the pellicle of the p.* Deciduous woods. Aug.—Oct. Uncommon. (*v.v.*)

1507*. **Russula Mairei** Sing. Sing. Arch. für Protistenkunde, 65 Band, Heft 3, t. 12, figs. 1–3.

René Maire, the eminent French mycologist.

P. 4–8·5 cm., *cinnabar or orange, disc paler, or having pallid or yellowish spots*, fleshy, convex, then subconcave, *more or less pruinose or velvety with the cystidia*; margin entire, subacute, or subrotund with age. St. 2·5–4·5 × 1–2 cm., *white*, at length subcinereous, variously shaped, flexuose. Gills *white, often becoming brown when injured*, sinuate, ventricose, often forked, many intermediate, crowded, becoming distant with age. Flesh *white, becoming brownish with age*, compact, *reacting lilac colour to a drop of sulphovanilla*. Spores *white*, elliptical, 9–9·5 × 7·5–8 $\mu$, verrucose, or cristulate, 1-guttulate. Cystidia elongate, ventricose, 65–95 × 7·5–10 $\mu$, obsoletely appendiculate, becoming blue with sulphovanilla. Taste *very acrid*. Smell *of apples*,

*like honey when dried.* On stumps, and at the base of beeches. Sept.—Oct. Uncommon. (*v.v.*)

1530. Russula drimeia Cke. (= *Russula sardonia* Fr. sec. Melzer & Zvára.) var. flavo-virens Rea. *Flavus*, yellow; *virens*, green.

Differs from the type in the *yellowish pileus becoming greenish with age.* Coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

1533. Russula violacea Quél. var. carneo-lilacina Bres. Bres. Iconog. Mycol. t. 444. *Carneus*, flesh coloured; *lilacina*, lilac colour.

Differs from the type in the *lilac-flesh colour of the p. becoming paler with age.* Woods. Sept.—Oct. Uncommon. (*v.v.*)

1546**. Russula sphagnophila Kauffm. (= *Russula betulina* Melzer, *Russula roseipes* Secr. var. Cke. Illus. no. 1035, t. 1081, sec. Singer.) Bull. Soc. Myc. Fr. XL (1924), t. 2, as *Russula paludosa* Britz. *Sphagnum*, Sphagnum; φίλος, loving.

P. 2–8·5 cm., *purplish red, or rosy red, pale olive-brown towards the margin*, convex, *umbonate*, soon expanded, then depressed, viscid, glabrous, pellicle separable, *very fragile*; margin thin, *subpellucid*, slightly striate. St. 4–9 cm. × 8–15 mm., *white tinged with rose colour*, expanding into the p., constricted below, and gradually thickened downwards to the base, rugose, *very fragile, very firmly attached by the basal mycelium.* Gills *white, then ochraceous, often coloured red on the edge near the margin of the p.*, adnato-decurrent or free, attenuated at both ends, sometimes forked, somewhat crowded. Flesh *white, reddish under the cuticle of the p. and st., brittle.* Spores *cream colour* in the mass, pale under the microscope, globose, 6–7 μ ("9·5–12 × 7·5–9·5 μ" Sing.; "8–10 × 7–8 μ" Melz.), echinulate, never cristulate; basidia 36–43 × 12·5–14·5 μ, sterigmata 7·5–11 μ long. Cystidia rather sparse, hyaline, ventricose, 65–80 × 9–11 μ, *with a very remarkably long pointed appendage*, 14–21 × 1·5–2·5 μ, the upper half bluing and the lower half becoming rose or pale with sulphovanilla. Smell slight. Taste mild. Heaths, moors and hillsides, especially under birches. June—Oct. Uncommon. (*v.v.*)

1549. Russula puellaris Fr. var. leprosa Bres. Bres. Fung. Trid. t. 65, and Iconog. Mycol. t. 455. *Leprosa*, rough.

Differs from the type in having *white, fugacious flocci on the p. when young, the less crowded gills and yellow flesh.* Under alders. Aug.—Oct. Uncommon. (*v.v.*)

1553. Russula alutacea (Pers.) Fr. var. vinoso-brunnea Bres. Bres. Iconog. Mycol. t. 460. *Vinosus*, wine colour; *brunnea*, brown.

Differs from the type in the *vinous brown colour of the p. and st.* Frondose woods. Aug.—Sept. Uncommon. (*v.v.*)

1553*. **Russula melliolens** (Quél.) Maire.
*Mel*, honey; *olens*, smelling.

P. 6–12 cm., *bright red, orange-red, flesh colour, salmon colour, bay to bay-purple, greyish violet, green, etc.*, convex, then expanded, often depressed, viscid, becoming dry, smooth, pellicle separable; margin rounded, often sulcate when old. St. 4–6 × 1–2 cm., *white, rarely tinged with rose*, subcylindrical, pruinose when young, rugose, striate. Gills *white, then cream colour, becoming finally brownish*, free or subfree, equal, very rarely forked, often connate by twos or threes, somewhat crowded, enlarged in front, attenuated behind. Flesh *white, becoming ochraceous brown*, firm or fragile especially in the st. Spores *pale cream in mass*, hyaline under the microscope, subglobose, 8–12 × 8–11 μ, *almost smooth*, the low warts either subreticulate, cristulate or irregular; basidia clavate, 40–50 × 10–14 μ. Cystidia generally *appendiculate*, 50–100 × 8–11 μ. Smell strong, *of honey* especially when old or dried. Taste *mild*. Deciduous woods. July—Oct. Uncommon. (*v.v.*)

var. **Christmantiae** Maire. Madame Christmant.

Differs from the red, firm form of the type in its *acrid taste*. Deciduous woods. Sept. Rare. (*v.v.*)

1716*. **Marasmius Friesii** (Bres.) Rea. (= *Collybia conigena* Fr. non Pers.) Bres. Iconog. Mycol. t. 214, fig. 2, as *Collybia Friesii* Bres.
Elias Fries, the eminent Swedish mycologist.

P. 1–3 cm., *greyish alutaceous*, fleshy-membranaceous, convex, then expanded, sometimes subumbonate, smooth; margin involute. St. 2–3 cm. × 1–2 mm., *concolorous, or somewhat* fuscous downwards, equal, *pulverulent*, base with a short, white villose root. Gills *white, becoming pallid*, rounded behind, free, crowded, edge entire. Flesh *concolorous*. Spores white, subcylindrical, 3·5–4 × 1·5–2 μ. Cystidia fusiform, ventricose, 25–30 × 9–12 μ. Smell and taste none. On unburied cones of *Pinus sylvestris*. Oct.—Feb. Common. (*v.v.*)

1939*. **Polyporus albosordescens** Rom. (= *Polyporus albus* Huds. sec. Bres.) Rom. in Svensk. Bot. Tidskr. 1912, Bd. 6, H. 3, p. 637, fig. 1.
*Albus*, white; *sordescens*, becoming dirty.

P. 8–18 cm., *white, becoming sometimes rose coloured, then yellowish*, dimidiate, somewhat hoof-shaped, gibbous, subimbricate, often effuso-reflexed, villose, rugose, rough, substrigose, zoneless; margin not or only slightly incurved. Tubes *white, then greyish, spotted with greenish blue, becoming finally brownish*, 1–3 cm. long; orifice of pores *white, then tinged with rose, violet or vinous, then finally blackish brown*, round, angular or flexuose. Flesh *white, then zoned with pale bistre, sometimes tinged with rose, lilac or greenish blue, becoming finally pure brown, subindurated, syrupy*, fleshy, fibrous, thick. Spores white, obovate, or

elliptical, obliquely attenuated at the base, 5–6 × 3–3·5 μ. Smell pleasant or none. Taste somewhat astringent. Apple, ash, beech, oak. Sept.—Oct. Uncommon. (*v.v.*)

2006. **Poria rufa** (Schrad.) Fr. (= *Poria taxicola* (Pers.) Brcs.) Rom. Svensk. Bot. Tidskr. 1912, Band 6, Heft 3, p. 642, fig. 3, as *Polyporus haematodes* Rostk. *Rufa*, red.

P. 2–8 cm., *pale brick colour, or blood-red-rufous, then blackish purple*, effused, membranaceous, thin, adnate, somewhat separable, even, smooth, determinate; margin *white*, byssoid, fairly wide or very narrow and almost none. Pores *concolorous*, rounded, *Merulius*-like, then deeper; orifice entire, obtuse, *fertile*. Spores white, cylindrical, curved, 3–4 (–5) × 1–1·5 μ; basidia 13–20 × 3–5 μ, with 2–4-sterigmata 2·5–3·5 μ long. Dead pine logs. Dec.—Jan. Uncommon. (*v.v.*)

2068*. **Trametes robiniophila** Murrill. Lloyd, Mycol. Notes, Syn. of the section Apus of the genus *Polyporus*, 314, fig. 635. *Robinia*, the locust tree; φίλος, loving.

P. 4–10 cm., *white*, dimidiate or ungulate, often imbricate, connate at the base, *smooth*, dull; margin *obtuse*. Pores *white, becoming isabelline*, 4–6 mm. long, round, minute. Flesh *white*, soft, "punky" sec. Lloyd. Spores white, subglobose, 7–8 μ, with a large central gutta. Trunks of *Robinia pseudacacia*. Jan.—Dec. Uncommon. (*v.v.*)

2134*. **Hydnum tubiforme** Gill. *Tubus*, a pipe; *forma*, shape.

P. 2–6 cm., *yellowish, or bright nankeen colour*, somewhat fleshy, convex, then expanded, regular, *more or less deeply umbilicate, then soon pierced at the disc by a circular opening which communicates with the inside of the st., subzonate, at first*, glabrous. St. 4–5 × 0·5–1 cm., *whitish, or yellowish, then concolorous*, equal, somewhat constricted at the apex, stuffed with a whitish pith, then hollow. Spines *yellowish*, unequal, 2–6 mm. long, acute, brittle. Flesh *white, or yellowish*, soft. Spores white in the mass, subglobose, apiculate, 7–8 × 7–7·5 μ, with a large central gutta. Smell slight. Taste pleasant then slightly acrid. Woods. October. Uncommon. (*v.v.*)

2404*. **Clavaria griseola** Rea. *v.* Pl. *Griseola*, grey.

R. 2–4 cm. high, *grey, becoming brownish when dry*, generally only twice or thrice branched; trunk expanding upwards into the branches, white floccose with the mycelium at the attenuated base. Branches rounded at the axils, apex *crescent-shaped*, acute. Flesh *white*, firm, tough. Spores white, globose, apiculate, 5–6 μ; basidia clavate, 30–35 × 7–8 μ, with 4-sterigmata. Amongst moss and bare soil in woods. September. Uncommon. (*v.v.*)

2493. **Tremella epigaea** B. & Br. = *Sebacina epigaea* (B. & Br.) Bourd. & Galz. *vide* no. 2516*.

2506*. Exidia Grambergii Neuhoff.

R. 3–9 cm. broad, 1–3 cm. high, *very black*, *very rarely flesh colour*, *umber or brown*, ear-shaped or shell-shaped, very slightly adnate on the underside. Hymenium *concolorous*, *strongly ribbed*, *deeply lacunose*, *glandular*, sometimes pruinose. Underside *opaque*, very roughly punctate, subtomentose. Flesh distinctly *cartilaginous* when moist and fresh, firm. Spores hyaline, cylindrical, curved, 13–17 × 5–5·5 μ. Hypobasidia subglobose, 16–20 × 14–17 μ, longitudinally divided. Living oaks, *caespitose*, *not confluent*, very rarely connate at the margin. Specimen from England in Herb. Berlin see Neuhoff, Zeits. f. Pilzkunde Bd. 5 (Neue Folge), p. 187.

2516*. Sebacina epigaea (B. & Br.) Bourd. & Galz. (= *Tremella epigaea* B. & Br.) ἐπίγαιος, upon the earth.

R. 2–3 mm., *greyish*, tuberculate, then pulvinate, confluent, spreading, 2–3 cm. in diam. Spores oblong, depressed, gibbous at the base, 8–11–14 × 4–8 μ, often 1-guttulate; basidia 12–18 (–22) × 10–12 (–16) μ, with 2–4-sterigmata, 30–100 × 1·5–3·5 μ; paraphyses simple or slightly branched. Hyphae thin-walled, 1·5–3 μ in diam. Bare soil, herbaceous stems, twigs, etc. Oct.—Jan. Uncommon. (*v.v.*)

2516**. Sebacina ambigua Bres. *Ambigua*, changeable.

R. *hyaline*, *milky opalescent*, effused in patches. Hymenium *concolorous*, tuberculate, sometimes subcerebriform. Flesh slimy, gelatinous, evanescent when dry. Spores hyaline, subglobose or broadly elliptical, 7–12 × 6–8 μ; basidia globose, then pyriform, 15–17 × 10–12 μ, with 2–3 flagelliform sterigmata, elongating to 80 μ or more. Hyphae 1–3 μ in diam. Burnt wood. Oct.–June. Rare.

2518*. Sebacina sphaerospora Bourd. & Galz. Bourd. & Galz. Hyménomycètes de Fr., p. 43, text-fig. 22.

σφαῖρα, a ball; σπορά, seed.

R. *hyaline to livid*, *opalescent*, *becoming sometimes reddish when dry*, widely effused, indeterminate, thin. Hymenium *concolorous*, smooth, tubercular or subcerebriform. Flesh waxy, subgelatinous, thin, often disappearing when dry. Spores hyaline, subglobose, apiculate at the base, 4–6 × 3·5–5·5 μ, guttulate; basidia obovate, 8–12 × 6–10 μ, with 2–4 sterigmata, 1–2 μ thick, elongating to 30 μ long. Hyphae indistinct, closely compacted, 0·5–2 μ. in diam. emerging as simple or branched paraphyses. Rotten pine and beech wood. Oct.—June. Rare.

2518**. Sebacina subhyalina Pears. Trans. Brit. Mycol. Soc. XIII (1928), p. 70, text-fig. 3. *Subhyalina*, somewhat transparent.

R. *hyaline-grey*, *or bluish opaline*, becoming black when dry, effused, indeterminate, fairly thick. Hymenium *concolorous*, smooth, slightly tubercular, or rarely subcerebriform. Flesh waxy-gelatinous, some-

times dry, often more or less slimy. Spores hyaline, cylindrical, slightly curved, 7–9 × 4–4·5 μ, 1–2-guttulate, or contents granular; basidia subglobose, longitudinally septate, 8–12 × 8 μ, with 2–4-flagelliform sterigmata, up to 40 × 2 μ long. Hyphae branched, 1·5–2 μ in diam. Old beech, birch, pine, etc. wood. Sept.—March. Common. (*v.v.*)

2520*. Sebacina (Bourdotia) Galzinii Bres. Trans. Brit. Mycol. Soc. XIII (1928), p. 72, text-fig. 4 and Bourd. & Galz. Hyménomycètes de Fr. p. 48, text-fig. 25, as *Bourdotia Galzinii* Bourd. & Galz.

A. Galzin, the well-known collaborator with L'Abbé H. Bourdot.

R. *whitish*, *opaline*, widely effused. Hymenium *concolorous*. Flesh gelatinous, viscid. Spores hyaline, obovate or elliptical, depressed on one side, 10–14 × 5–7·5 μ, average 10 × 5 μ; basidia ovoid-clavate, 16–24 × 8–12 μ, with flagelliform sterigmata. Gloeocystidia narrow, flexuose, tubular, 90–270 × 4–9 μ, filled with yellow oil granules, traversing the trama perpendicularly. Hyphae agglutinated. Rotten wood. Jan.—Dec. Rare.

2522***. Tulasnella calospora (Boud.) Juel. (= *Prototremella calospora* Boud.) Trans. Brit. Mycol. Soc. XIII (1928), 73, text-fig. 5.

καλός, beautiful; σπορά, seed.

R. *grey with an opalescent tinge*, effused in irregular patches. Hymenium *concolorous*, floccose under a lens with the spores. Flesh waxy, thick. Spores hyaline, fusiform, somewhat curved, 24 × 4 μ ("20–28 × 5–8 μ" Boud., "26–45 × 4–6 μ" Bres.), contents granular, 1–multi-guttulate; basidia ovate, then elongated, narrow, 12 × 9 μ, with 4-sterigmata. Hyphae circ. 3 μ in diam., septate. On the ground, rags, and oak wood. Nov.—Feb. Rare.

2524*. Tulasnella sordida Bourd. & Galz. Trans. Brit. Mycol. Soc. XIII (1928), 73, text-fig. 6; Bourd. & Galz. Hyménomycètes de Fr. p. 62, text-fig. 39.

*Sordida*, dirty.

R. 20 × 8 cm., *pale smoke or faint lilac colour, often drying up to a delicate lilac film*, widely effused. Hymenium *concolorous*, smooth, or slightly tuberculate. Flesh waxy, slimy, thin, often evanescent. Spores hyaline, broadly obovate, apiculate, 5–12 × 4–8 μ, mostly 8 × 6 μ, contents densely granular; basidia obovate, 8–30 × 6–12 μ, with 2–4-sterigmata, ovate, 9–10 × 4–5 μ, then obovate and elongate at the apex, 10–15 × 4–5 μ. Hyphae 2–7 μ in diam., septate, no clamp connections, with some bulbous swellings. Rotten, decorticated oak log. Jan.—Dec. Not rare.

## LATIN DIAGNOSES

192. Psaliota campestris (Linn.) Fr. var. squamulosa Rea.

A typo differt pileo squamulis fuscis vel cinereis, adpressis obtecto. In pratis et collibus. Jun.—Oct. Haud raro.

192*. Psaliota flocculosa Rea.

Totus niveus. P. 5–7 cm. latus, carnosus, e campanulato-convexo expansus, squamis concoloribus, imbricatis, floccosis dense obtectus, margine lamellas excedente, e velo partiali appendiculato. St. 6–8 cm. longus, 1·5–2 cm. crassus, seorsim incrassatus, basi attenuatus, solidus, sericeus, infra annulum leviter squamosis tectus. Annulus membranaceus, angustus, subdistans. Lamellae ex albis purpureae, liberae, angustae, 4–5 mm. latae, subconfertae. Caro alba, immutabilis, crassa, tenax, ad latera tenuis, lamellas excedens. Sporae purpureae, late ellipticae, 7–9 × 5–6 $\mu$, uniguttulatae, poro apicali praeditae. Odor nullus. Sapor gratus. In pascuis sub betulis. Oct. Raro.

197*. Psaliota impudica Rea.

P. 5–10 cm. latus, fusco-rufus vel fuscidulus, e ovato-campanulato expansus, squamis obscurioribus, adpressis, fibrillosis obtectus, centro laevi, margine primo incurvo, lamellas excedente. St. 6–11 cm. longus, 1–2 cm. crassus, albus, aequalis, basi saepe plus vel minus bulbosus, sericeus. Annulus albus, persistens, superus, membranaceus. Lamellae ex albis carneo-rosae demumque fusco-purpureae, liberae, 4–8 mm. latae, confertae. Caro alba, semper immutabilis, tenax. Sporae in cumulo fusco-purpureae, ellipticae, sub basi apiculatae, 4–5 × 3 $\mu$, intus gutta media, crassa repletae. Odor et sapor gratus. Esculenta. In sylvis et pascuis. Jul.—Nov. Sat frequens.

1083*. Leptonia acuta Rea.

P. 2–2·5 cm. latus, cinereo-fuscus, carnosulus, conico-campanulatus, 1·5 cm. altus, eximie umbonatus, innato-fibrillosus, margine incurvo. St. 4 cm. longus, 3–4 mm. crassus, albus, aequalis, glaber. Lamellae ex albis carneo-rosae, adnexae, antice attenuatae, postice ventricosae, subconfertae. Caro alba, sub pellicula pilei fusca, centro crassa, ad latera tenuis. Sporae roseae, 6-angulatae, 9–10 × 7–8 $\mu$, intus gutta media, crassa repletae. Odor leviter farinae recentis. In herbidis muscosis et ericetis sub pinis. Oct. Raro.

2404*. Clavaria griseola Rea.

R. 2–4 cm. altum, griseum, siccitate fuscum, saepenumero bis terve furcatum; truncus sursum in ramos dilatatus, basi attenuatus, et albofloccosus ex mycelio. Rami arcuati, apicibus lunatis, acutis. Caro alba, rigida, tenax. Sporae albae, globosae, apiculatae, 5–6 $\mu$; basidia clavata, 30–35 × 7–8 $\mu$; sterigmata 4. In sylvis ad terram nudam et inter muscos. Sept. Haud raro.

## COLOURED PLATE

*Psaliota flocculosa* Rea
*Inocybe maculata* Boud.
*Clitocybe paradoxa* Cost. & Duf.
*Flammula limulata* Fr.
*Leptonia acuta* Rea
*Clavaria griseola* Rea

Basidia 25–35
× 7–10μ
Marginal cells 30–40
× 15–18μ
8–11×5–7μ
Psaliota flocculosa Rea
Inocybe maculata Boud.
7–9 × 5–6μ
9–10 × 7–8μ
Leptonia acuta Rea
Tinted
with iodine
7–8 × 4–5μ
tocybe paradoxa Cost. & Duf.
External
hairs
5–6μ
idia
7–8μ
Clavaria griseola Rea
Flammula limulata Fr.
7–8 × 4–4·5μ
V. Rea, del.

# A *FOMES* WITH TWO SYSTEMS OF HYPHAE

By E. J. H. CORNER
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(With 13 Text-figures)

Of the five systems of hyphae in the fruit body of *Polystictus xanthopus** only the skeletal, binding and generative systems are characteristic; they are the result of division of labour in the common arrangement in which all the hyphae having the same structure and function belong to one system. For, of the other two, that of the mycelium must occur in all, and a skeletal system implies a mediate, though it vary in extent as the transition from generative to skeletal hyphae is gradual or abrupt. It is convenient for comparison to say thus that such a fruit body is composed of three systems of hyphae, or that it is *trimitic* (μίτος, a thread of the warp). Similarly the species of *Fomes* which I have now examined, has but two systems (*dimitic*) and in this respect is at a lower level of evolution; it has skeletal and generative hyphae essentially as in *P. xanthopus*, but a binding system is not differentiated.

The dimitic construction seems to be general in the section of *Fomes* with brown woody flesh, and I have observed it in *F. rimosus*, *F. pectinatus*, *F. senex*, *F. setulosus*, *F. lamaensis* and *F. pachyphloeus*. The trimitic construction is characteristic of the coriaceous species of *Polystictus* and, perhaps, of the corky and felted fruit bodies of *Trametes*, *Hexagonia* and *Daedalea*, but no classification is discriminating enough for a definite statement, and both kinds, in addition to the ordinary *monomitic* construction, are to be met with in *Polyporus*.

The species described in this paper has been fruiting for the past two years on a log in the Singapore Botanic Gardens, and the opportunity of investigating the structure and biology of a *Fomes* with such abundant material close at hand was not to be missed. But I find it must be described as new. It is very like *F. senex* and *Polyporus gilvus* but it has distinctive microscopic features, which will be considered at length at the end of the paper along with the related species. It does not appear to be common in Malaya though widespread in the lowland forest.

In the text-figures, the indurated yellow-brown walls of the hyphae, so characteristic of this section of *Fomes*, have been drawn as thick black lines, and by this means the skeletal hyphae are easily distinguishable from the generative. Where the lumen of a skeletal

* *Ann. Bot.* XLVI (1932), 71.

hypha has disappeared through the thickening of the wall, the hypha has been drawn naturally as a black rod.

To investigate the hyphal system in dried herbarium material the best method is to mount the sections in dilute potash (5 per cent.). The thin-walled hyphae, which have collapsed in the drying, are swollen out to their natural size and the thick-walled yellow-brown elements are rendered more conspicuous by turning to a very dark colour.

*Fomes levigatus*, n.sp.

Pileus *sessilis*, basim versus saepe angustatus sed raro substipitatus, *applanatus*, vix ascendens, dimidiatus, plerumque postice breviter resupinato-effusus, rigidus, antice subvelutinus dein *levigatus*, *impolitus aut subnitidus*, in *senectute postice subtuberculatus*, vix sulcatus, *haud zonatus*, raro subzonatus, *laete castaneo-brunneus demum umbrinus*, siccus cinnamomeo-umbrinus, usque 7·5 cm. radio, 13·5 cm. latus: *margine* obtuso raro subacuto, velutino, *laete aureo-fulvo*.

Substantia paullum crassa, lignosa, vix suberosa, *saturo fusco-ferruginea*, sicca dura et cinnamomeo-brunnea, postice 2–9·5 mm. crassa, 5 mm. de margine 1–4 mm. crassa: *crusta superficiali* tenui, *coriacea*, *fusca*, nec nigra nec carbonacea, demum usque 800 $\mu$ crassa, praedita.

Tubuli *breves*, *fusco-ferruginei*, postice 2–2·5 mm. longi, 5 mm. de margine 0·3–0·5 mm. longi: *poris minutis*, rotundis, velutinosis, *fusco-ferrugineis*, 65–95 $\mu$ latis, dissepimentis 30–75 $\mu$ crassis.

Sporae *albae*, ellipsoideae, unilateraliter applanatae, leves, tenuiter tunicatae, intus gutta una parvula 0·5 $\mu$ lata praeditae, 3·5–4 × 2·5$\mu$.

Basidia subcylindrica, tenuiter tunicata, intus vacuolata, 9–11 × 3–4 $\mu$: sterigmatis 4, 1·5–2 $\mu$ longis.

Cystidia vix numerosa, parva, subventricosa aut subcylindrica, hyalina, tenuiter tunicata, intus vacuolata, apicibus attenuatis acutis filiformibus saepe setis connitentibus, 16–25 $\mu$ longa, 2–3·5 $\mu$ lata, apicibus 1 $\mu$ latis.

Setae numerosae, conicae, subventricosae, crasse tunicatae, fusco-ferrugineae, apicibus pallidis vel hyalinis acutis rectis, 13–26 × 5–7 $\mu$.

Hyphae skeletales *crasse tunicatae*, *aseptatae*, *haud ramosae*, parietibus laete ferrugineis 1–2 $\mu$ crassis praeditae, luminibus plus minus occlusis, 3–5 $\mu$ latae.

Hab. ad truncos emortuos, pileis imbricatis saepe lateraliter conjunctis, Malaya (Singapore, Johore, Penang, Perlis).

Singapore Field No. 23709, from the Botanic Gardens, is the type collection. Sing. F. No. 5619, det. C. G. Lloyd as *Polyporus carneo-fulvus* Berk., belongs to this species.

The colour of the fresh pileus is a rich burnt umber becoming dark umber when old and cinnamon-bay when dry: the flesh is dark rich ferruginous: the pores and tubes are dark date-brown.

Text-fig. 1. *F. levigatus*. *a*, skeletal hyphae; *b*, generative hyphae; *c*, a mediate hypha; *d*, three skeletal hyphae at their origin from mediate and generative hyphae. × 500.

### Systems of hyphae

*Skeletal hyphae*: 3–5 μ wide, cylindric, *unbranched*, *aseptate*, often flexuous, sometimes curled or kinked, rarely with short spine-like projections (up to 10 μ long), *radiating* though often oblique, with smooth *dark yellow-brown walls*, 1–2 μ thick, and narrow lumen becoming linear or occluded in old parts: growing apices pale yellowish or colourless, cylindric, rounded, obtuse, thin-walled, not tapering (Text-fig. 1 *a*).

The walls of the skeletal hyphae stiffen about 10–25 μ behind the apex, and at 30–50 μ back the wall is about 0·5 μ thick, whence it gradually thickens, and at 100–200 μ back it is about 1 μ thick. The walls are often slightly and irregularly wavy owing to unequal thickening. The contents of the hyphae at the apex appear very viscous, smeary colloidal, with numerous small vacuoles.

*Generative hyphae*: 1·5–3 μ wide, cylindric, *branched*, *septate without clamps*, with thin colourless walls or more usually with the walls firm, very slightly thickened, pale yellow or brownish and often slightly wavy as those of the skeletal hyphae: radiating or interwoven, sparingly or frequently branched, the branches often growing parallel with the parent hypha for some distance: apices obtuse, thin-walled, colourless, full of dense protoplasm rather more fluid than in the skeletal hyphae: septa at intervals of 25–300 μ, mostly 50–180 μ, but very variable: H-connections frequent (Text-figs. 1 *b*; 2 *c*, *d*).

The walls of the generative hyphae remain thin for some distance behind the apex and first begin to stiffen about 100–200 μ back. In the old parts of the flesh, especially just above the tubes, the walls may become as much as 1 μ thick.

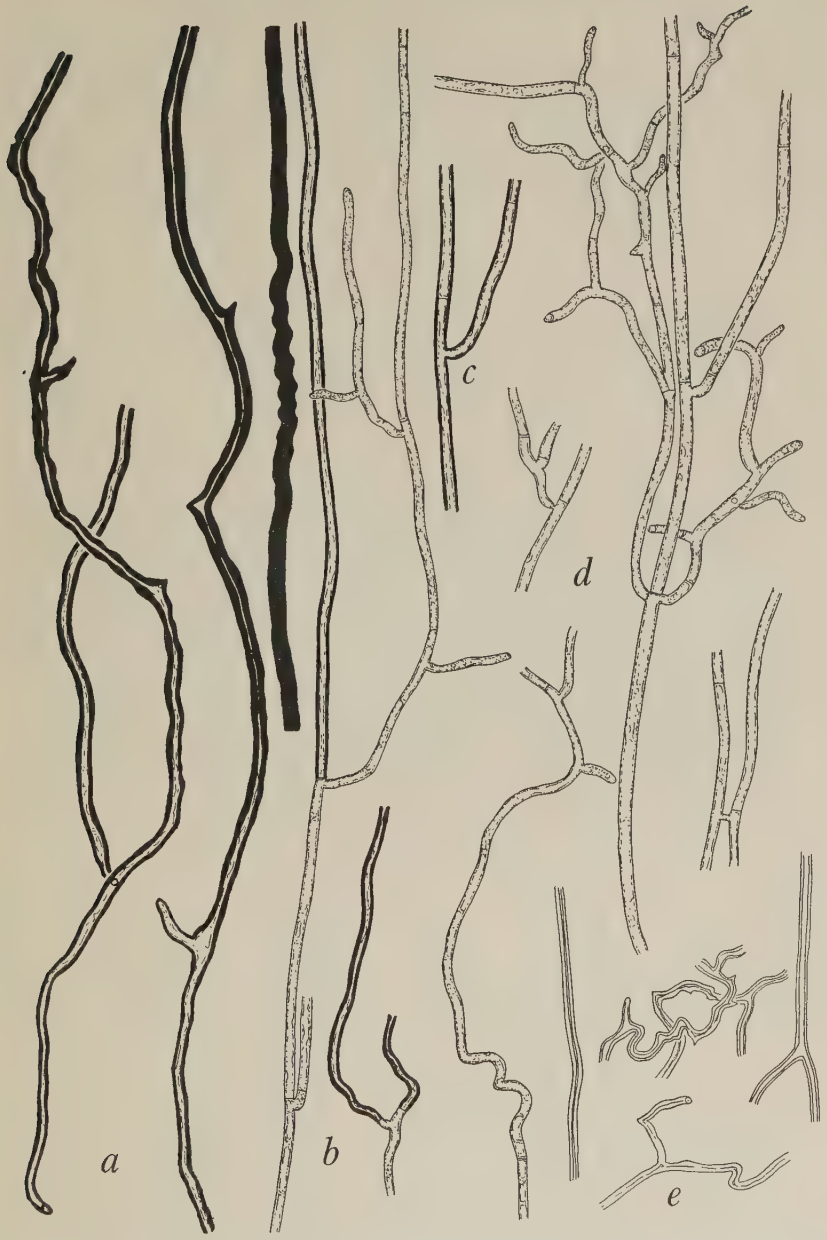
*Mediate hyphae*: 2·5–3·5 μ wide, cylindric, rarely branched, rarely septate, radiating or oblique, often flexuous or kinked, with pale yellow-brown walls *ca.* 0·5 μ thick (Text-figs. 1 *c*; 2 *a*).

The apices are similar to those of the generative hyphae, but the wall begins to stiffen and colour up at 35–100 μ from the apex.

*Mycelial hyphae*: 1–2 μ wide, very fine, branched, septate, without clamps, straight or flexuous, often subnodular, with thin colourless hyaline walls, sometimes slightly thickened and yellowish in the old hyphae.

*Stuffing hyphae*: 1·5–2·5 μ wide, *narrow*, rather sparingly branched, *aseptate*, with thin nearly colourless or more or less strongly thickened and pale yellowish walls, sometimes nearly solid, often flexuous, nodular or kinked but mostly stiffly straight (Text-fig. 2 *e*).

These hyphae occur only in the old tubes the effete portions of which they fill in with a pale yellow wadding. They are derived partly from the generative hyphae of the dissepiments, but mostly, it seems, from the mycelium. In many species of *Fomes* and *Ganoderma*




Text-fig. 2. *F. levigatus*. *a*, mediate hyphae; *b*, mediate hyphae at their origin from generative hyphae; *c*, a thick-walled generative hypha from the oldest tissue of the pileus; *d*, thin-walled generative hyphae from near the margin; *e*, stuffing hyphae. × 500.

the mycelial hyphae grow into the old flesh from the base of the fruit body and cause a partial or complete autolysis of the original tissue, the hyphal walls being eroded in the same way as in the starved fruit bodies of *P. xanthopus*, and eventually they form fairly conspicuous white or yellowish strands and penetrate into the tubes. In *F. levigatus* the strands are poorly developed and there is little autolysis: the mycelial hyphae are not characteristic and it is impossible to trace them individually through the tissue.

### Interrelations of the hyphae

The origin of the skeletal hyphae from the generative hyphae can be observed directly in this species, since the transitional region is short, and need not be inferred as in *P. xanthopus*. The generative hyphae lose the power of septation, become rather thick-walled and stop branching. They thus become mediate hyphae. Their apices then enlarge slightly and the wall thickens more strongly and they become skeletal hyphae. The transition may be effected in as short a distance as 50 $\mu$, when the skeletal hyphae practically arise directly from the generative hyphae, as in Text-fig. 1 *d*, but more frequently in a distance of 100–300 $\mu$, as in Text-fig. 2 *a*, *b*. Sometimes it seems that the mediate hyphae may grow for several millimetres before becoming skeletal elements, and possibly some persist indefinitely in this state. Similarly it appears that the transition from generative to mediate hyphae may be delayed because elements with the appearance of narrow, distantly septate mediate hyphae may occasionally be seen.

The skeletal hyphae always arise at the growing margin of the bracket. Though I searched carefully, I found no evidence that laterals of the generative hyphae in the mature flesh ever became mediate or skeletal elements in the manner of origin of binding hyphae.

The skeletal hyphae of the dissepiments also arise from the generative hyphae, but apparently without mediate elements. However, it is difficult to trace their origin owing to the very intricate growth of the hyphae in that part of the flesh which overlays the tubes.

### The structure of the mature tissues

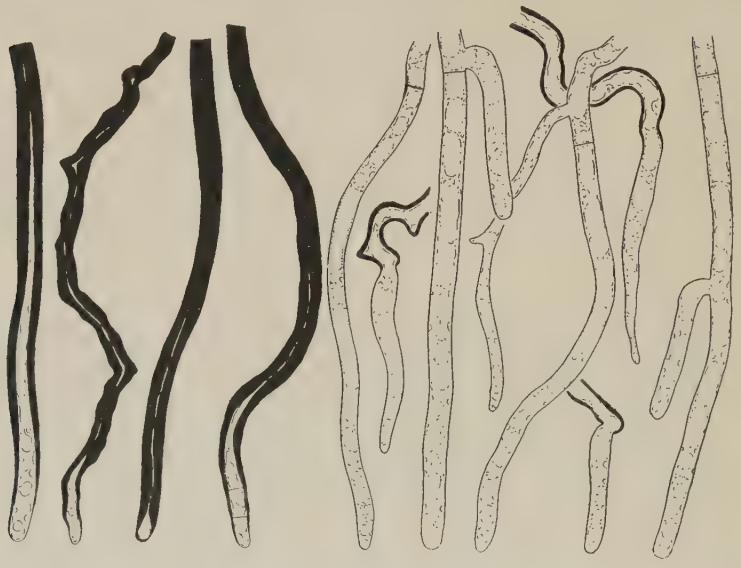
The mature flesh is composed of fairly closely interwoven skeletal and generative hyphae. Their direction is chiefly radial but many pass transversely, or obliquely, to the upper and lower surfaces, or even occasionally backward, so the texture is felted rather than fibrillar. Immediately above the tubes the tissue is denser on account of the profuse branching of the generative hyphae which takes place in this region near the margin of the pileus.

On the upper side of the pileus there is a thin crust which is often scarcely visible to the naked eye, though its presence might be guessed from the peculiar dull, smooth appearance of the surface. It is about 20–30 $\mu$ thick at a distance of 1–2 cm. from the margin, and at the base of the pileus it may be as much as 800 $\mu$ thick. It is composed of very intricately and irregularly interwoven, contiguous generative hyphae with slightly thickened pale yellowish or brownish, agglutinated walls without air-spaces between them. The ends of the skeletal hyphae project shortly—up to 30 $\mu$—into the crust, and here and there embedded in the thicker parts are short flexuous skeletal hyphae up to 200 $\mu$ long, orientated more or less vertically, and scattered singly or in small groups. The walls of the generative hyphae never become dark brown or carbonaceous, so that the crust is rather soft and leathery and not of the hard, black, stony consistency which is usual in *Fomes*.

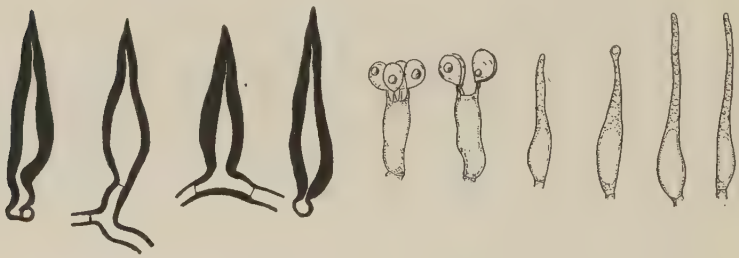
Text-fig. 3. *F. levigatus*. The crust on the upper side of the pileus about 1 cm. from the margin. × 500.

The dissepiments are composed of compact skeletal hyphae with longitudinal and interwoven generative hyphae among them. At the ends of the dissepiments the hyphal apices form a regular palisade and are not turned aside as in *P. xanthopus*. The skeletal hyphae of the dissepiments differ in some minor points from those of the flesh. They are narrower, being 2–3 $\mu$ wide, more or less strongly flexuous, frequently kinked and nodular, and their walls thicken nearer to the apex. Thus, in newly formed dissepiments up to 200 $\mu$ long, the walls begin to thicken about 10 $\mu$ from the apex and are completely thickened with the lumen linear or wholly occluded at 50–100 $\mu$ back: in older dissepiments of slower growth the walls begin to thicken at 2–8 $\mu$ from the apex and are fully thickened at 10–30 $\mu$ back: while in some specimens, in which growth has probably ceased, however, even the apex itself is slightly thick-walled. A few of these hyphae also have 1–3 septa at the apex, but they are soon re-absorbed, as in

*P. xanthopus* (cf. Text-fig. 4). The narrowness and dense arrangement of these nearly solid, dark yellow-brown skeletal hyphae not only cause the colour of the tubes to be considerably deeper than that of the flesh, but make them harder and woodier. The generative hyphae are affected in a similar manner. At the base of the dissepiments,



Text-fig. 4. *F. levigatus*. Skeletal hyphae from the ends of the dissepiments and generative hyphae from the pore field. × 1000.



Text-fig. 5. *F. levigatus*. Setae, basidia and cystidia. × 1000.

where they descend from the flesh, the generative hyphae may have their walls so much thickened that the lumen is nearly obliterated, and being interwoven and subnodular they thus have incipiently the character of binding hyphae.

The hymenium is continuous over the dissepiments down to a distance of 30–100 $\mu$ from the pores. The subhymenium is very slightly

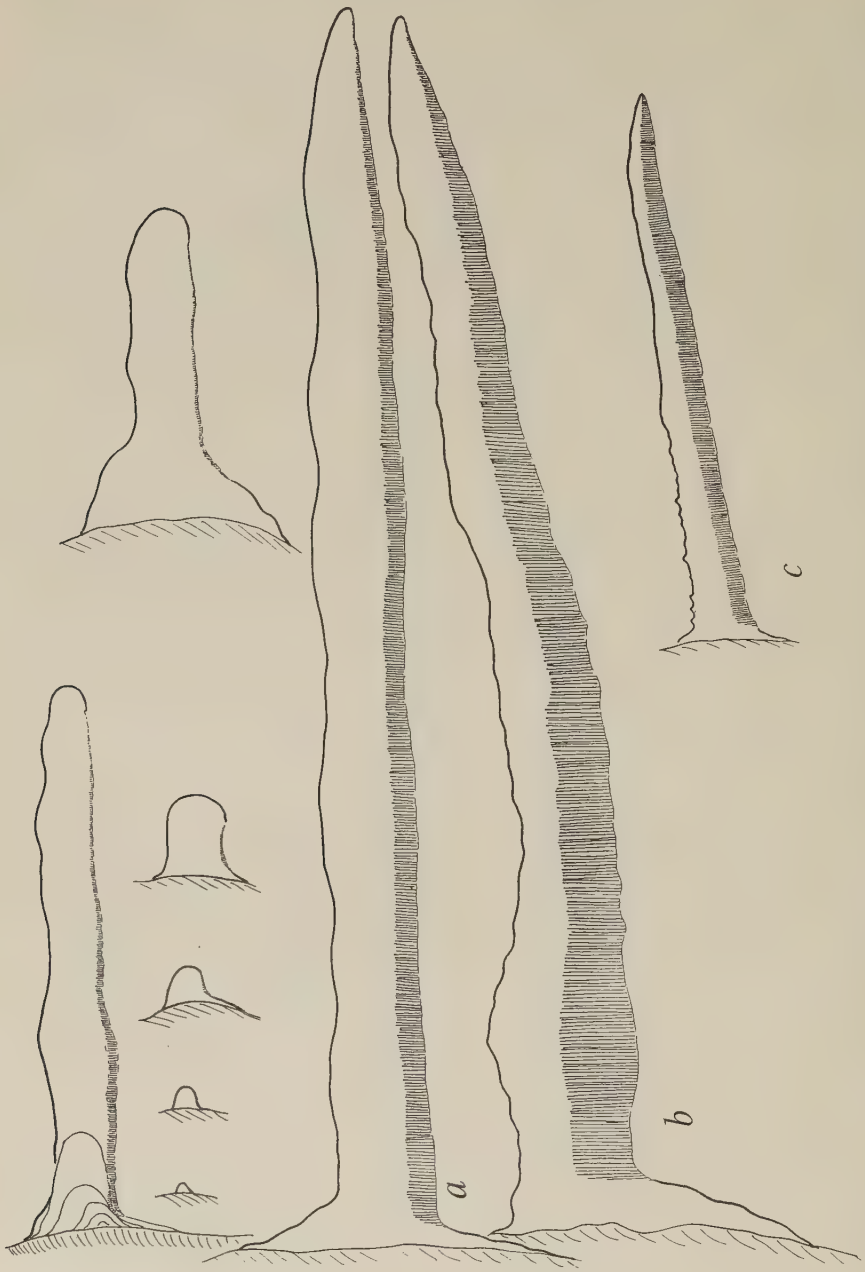
developed, 1–2 hyphae thick, and consists of colourless, thin-walled generative hyphae, 1–2·5 $\mu$ wide: it is best developed over the upper ends of the tubes. The setae arise at the ends of thick-walled generative hyphae, while the true cystidia arise as the basidia from thin-walled, colourless generative hyphae.

Basidia begin to mature almost as soon as the downgrowth of the dissepiments has started, but in the longer tubes the hymenium is fertile only for a distance of $\frac{1}{2}$–1 mm. from the pores. The upper parts, as already described, are filled in by the stuffing hyphae, and the old basidia, instead of collapsing and disappearing, develop slightly thickened, pale yellowish walls and become cemented together to form a pavement-like layer: the hymenium thus persists long after it is functionless. The same can be seen also in many other species of *Fomes*.

### The development of the fruit body

As in *P. xanthopus* the primordium first appears as a small fleck on the wood and rapidly enlarges into a hemispherical body, 1–6 mm. high. It is a bright tawny yellow and is composed of skeletal and generative hyphae which grow out in all directions at the surface so that the tissue is felted. The outgrowth soon slackens on the upper and lower sides but continues vigorously in the intermediate band-like region, and the primordium spreads out as a semicircular bracket (Text-fig. 6). The direction of marginal growth is horizontal or very slightly ascending, in which case the tubes, on growing vertically, appear to be inclined backward a little and their axes make an acute angle with the radius of the bracket. As marginal growth proceeds, the sides of the bracket are pressed firmly against the wood and may become attached to it by a small amount of secondary mycelium. At the base of the bracket the tissue thickens slowly for some time and often the lower margin on the under side spreads out as a thin sterile sheet, or resupinate "foot," for a distance of 10–15 mm., and possibly continues to spread very slowly throughout the life of the fruit body. By these means the bracket acquires a greater purchase on the support, which in *P. xanthopus* is provided by the discoid expansion at the base of the stem. On the other hand the flesh of the limb scarcely thickens at all behind the margin, but remains remarkably even until it tapers off rapidly on cessation of growth.

The tubes may develop when the bracket is barely 2 mm. in radius or not until it has reached 10 mm., according to the size of the primordium. The downgrowth of the dissepiments proceeds very slowly for several weeks after their inception in the pore field, and a common pore level is thus attained only in the proximal half of the bracket.




Text-fig. 6. Stages in the development of the fruit body of *F. levigatus* in radial section: *a*, a mature fruit body; *b*, a fruit body of *F. senex* in the first season; *c*, a fruit body of *Polyporus gilvus* var. *licnoides*. × 2.

The margin of the bracket, when fresh, is lurid golden yellow and rather coarsely velutinate. It consists of the radiating ends of skeletal, mediate and generative hyphae which are drawn up compactly to an even front. But as apical growth slackens in the hyphae situated near the upper and lower surfaces, their distal portions are pushed aside by the new branches formed in the middle region, and on cessation of growth many of them become curved or hooked, crozier fashion, at the ends. Shortly behind the margin, also, the generative hyphae give off numerous laterals many of which become mediate and skeletal hyphae, and these grow through the tissue radially or obliquely, as best they may between the preformed elements, and reach the margin or the upper or lower surfaces. It thus comes about that these surfaces, just behind the margin, consist of hyphal ends which project outward in any direction and give the coarsely velutinate appearance. Then, through the activity of the generative system, the crust develops on the upper side and the tubes on the lower side.

### The development of the crust

On the upper side, at 2–3 mm. from the margin, after the general outgrowth has stopped, thin-walled colourless hyphal processes, 1·5–3 $\mu$ wide, arise from the generative hyphae which lie near the surface, and they grow between the ends of the skeletal and mediate hyphae. Either they apply themselves directly round the ends of these thick-walled elements and by lobing and branching very irregularly weave them into the compact tissue of the crust, or they grow straight beyond the general level for a distance of 20–30 $\mu$ before they are deflected and begin to interweave, in which case a delicate canopy is at first formed, and subsequently, by the ingrowth of branches and lobes, the tissue is built back to the flesh and incorporates the ends of the thick-walled elements. The walls of these hyaline hyphae then thicken and agglutinate by squeezing out or absorbing the air between them, and a crust is formed which has the appearance already described (cf. Text-fig. 3).

In some fruit bodies the crust thickens no further. Usually it continues in the same manner. Either short hyphal processes continually grow out for distances up to 20 $\mu$ and then branch, lobe and unite with each other, thus gradually extending the crust: or, as appears to happen in spells of very wet weather which follow on a dry week or two, the processes grow out for a distance of 60–70 $\mu$ in a loose palisade or in groups, giving a fine bloom to the surface, and then form another layer of crust as before, only it rarely happens here that the new layer is built back completely to the old, and a crust, thickened in this manner, shows in section the agglutinated plectenchyma with groups or strips of vertical generative hyphae loosely arranged within it. The small tubercles on the upper side of old fruit

bodies also arise by such local excrescence, and probably at such times the generative hyphae produce the skeletal hyphae which may occasionally be found in the old crusts.

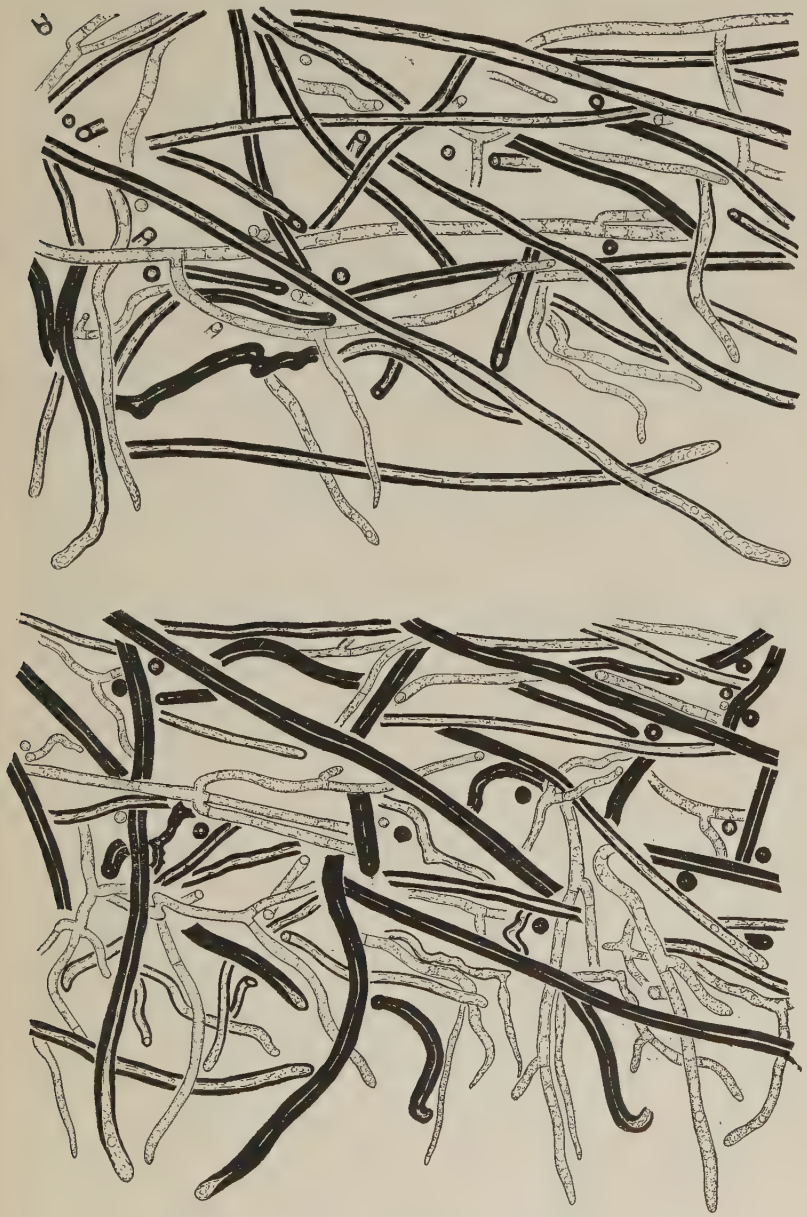
### The development of the tubes

The skeletal and mediate hyphae on the lower side of the margin appear to grow out for a longer time than those on the upper side, and on cessation of growth they are not arrested so definitely at a common level. The posterior border of the coarsely velutinate margin passes on the lower side into a very finely velutinate, narrow, dark brown zone, which is the pore field, and at the posterior border of this zone, in turn, at 1·5–2 mm. from the margin, the dissepiments begin to develop. The compactness of the pore field, which is only about 500 $\mu$ wide, is due to the great amount of branching among the generative hyphae in the lower layer of the flesh and the outgrowth of these laterals at the surface: it is already dark brown like the mature pores, because many of these laterals have begun to develop into the skeletal hyphae of the dissepiments and to acquire the thick, dark yellow-brown walls. The superficial appearance of the pore field is essentially the same as in *P. xanthopus*.

I have explored in great detail the very complicated behaviour of the hyphae in the pore field and have reconstructed from sections and teased-out fragments six stages in the development of a dissepiment. The drawings are as faithful as possible though some liberty has been taken in representing the longer hyphae as if they lie in one plane, whereas in reality they wander to and fro and one must focus up and down in the section to follow them even for short distances: but a facsimile would be but a meaningless display of chips.

The first three stages are taken from sections of corresponding parts of the flesh and they show how the pore field develops by a downgrowth of hyphae from the lowest layer of the flesh. The last three stages are taken from the extreme surface and they show the special outgrowth of the dissepiment. A corresponding level in all six stages can be obtained by drawing a horizontal line through the tips of the stout skeletal hyphae which project from the flesh: thus, to combine the last stage with the first, the base of the dissepiment in the lower figure of Text-fig. 9 should be placed on a line joining the two lowest tips of the skeletal hyphae in the upper figure of Text-fig. 7, and this level corresponds with that reached by the excrescent skeletal hyphae in the coarsely velutinate under side of the margin immediately anterior to the pore field: it is the limit to which the flesh is built out on the under side.

In the first stage (Text-fig. 7, upper figure), taken about 900 $\mu$ from the margin, the skeletal hyphae have almost stopped growing, and



Text-fig. 7. *F. levigatus*. For explanation see text. × 500.

as yet there are few laterals from the generative hyphae: so the tissue is loose and the surface coarsely velutinate.

In the second stage (Text-fig. 7, lower figure), at *ca.* 1300 $\mu$ from the margin, the projecting skeletal hyphae have definitely stopped growing and their apices are becoming thick-walled. The main generative hyphae have produced many laterals which are interweaving or growing downwards with their ends projecting freely, and some of them are already developing into narrow skeletal hyphae. The tissue is becoming felted and finely velutinate in surface view.

The third stage (Text-fig. 8, upper figure), at *ca.* 1600 $\mu$ from the margin, represents the middle of the pore field. Very numerous laterals of the generative hyphae have grown down and brought the general level of the flesh to that of tips of the skeletal hyphae, which have thus been incorporated in the tissue. Many of the laterals remain thin-walled, but in others the walls have become more or less indurated and yellowish brown and yet others have become narrow skeletal hyphae. Some have grown nearly vertically downward and point fairly straight from the surface, but the majority, and especially the narrow skeletals, are more or less interwoven having grown in any direction except back again into the flesh. Such lack of direction must mean that the hyphal tips are not yet definitely geotropic.

The fourth stage (Text-fig. 8, lower figure), at *ca.* 2000 $\mu$ from the margin, shows the very beginning of a dissepiment. In the middle of the section the excrescent hyphae are crowded, projecting slightly beyond the general surface, and their direction of growth is more distinctly downward. This configuration means that in a certain region the production of narrow skeletal hyphae has been increased, that both the narrow skeletal and the generative hyphae of the same region have been stimulated to further outgrowth and that they are becoming positively geotropic. It is the first sign of the operation of the force in the pore field which creates the dissepiments (and incidentally the tubes).

In the fifth stage (Text-fig. 9, upper figure), at *ca.* 2500 $\mu$ from the margin, the dissepiment is clearly defined. It is a short column, about 60 $\mu$ long, of downgrowing narrow skeletal and generative hyphae. In the intervals between the dissepiments, over the blind upper ends of the tubes, the hymenium has developed and some basidia have even ripened spores. In these parts the downgrowth of the thin-walled generative hyphae is arrested; the terminal cell enlarges into a basidium or a cystidium, then laterals from the subterminal cells build up the hymenium in the usual manner by further sympodial branching, and the subterminal cells of the hyphae form the subhymenium.

Finally, in the sixth stage, at *ca.* 3500 $\mu$ from the margin, the dissepiment is about 120 $\mu$ long and the hymenium has begun to de-

velop over the sides. It is constructed in the same way as in *P. xanthopus* by the downward creep of the subhymenial hyphae and from laterals of the generative hyphae in the dissepiment itself. Many of

Text-fig. 8. *F. levigatus*. For explanation see text. × 500.

the generative hyphae at the base of the dissepiment and in the flesh immediately above have become thick-walled and rather intricately interwoven, even irregularly lobed, and in thus assuming to a small

extent the appearance and function of the binding hyphae of *P. xanthopus* they help to strengthen the layer of flesh above the tubes. The

Text-fig. 9. *F. levigatus*. For explanation see text. × 500.

setae are formed at the ends of these thick-walled generative hyphae where they reach the surface, never while embedded in the tissue: the ends, which are thin-walled for a short distance, swell into the

conical or ventricose shape and when full-sized the wall thickens and becomes yellow-brown from the base to the apex which, however, usually remains colourless: setae may also be formed on short diverticula and they then appear forked at the base.

To summarise: there are three kinds of hyphal end in the pore field. First, there are the wide, blunt, yellow-brown ends of the skeletal and mediate hyphae the walls of which thicken rapidly behind the apex: they are the ends of the hyphae from the margin of the bracket which have dropped behind on the lower side and have stopped growing; so they project in any direction but mostly obliquely forward, in the direction of marginal growth, and they are often curved. Secondly there are the narrow ends of the laterals of the main generative hyphae; they have grown from the lower layer of the flesh and are colourless and thin-walled, 1·5–3 $\mu$ wide, and cylindric or tapering. Thirdly there are the narrow ends of the skeletal hyphae of the dissepiments; they are colourless or yellow-brown, 2–3 $\mu$ wide, cylindric or tapering, and their walls thicken shortly behind the apex. But, as is to be expected in this developing region, there are many other hyphae of character intermediate between the generative and skeletal hyphae, being generative hyphae in the process of becoming the skeletals of the dissepiments, and by confusing the identification of each kind they make impossible an exact analysis of the behaviour of the different elements. Moreover there are irregularities in the deportment of the generative hyphae; for some of them stop growing and their walls thicken up to the apex, and then delicate, colourless processes are frequently extruded which grow on as ordinary generative hyphae and apparently contribute to the hymenium (cf. Text-fig. 4).

The three kinds of hyphal end appear in fairly definite sequence. Immediately behind the margin there are only the skeletal and mediate hyphae of the flesh with a few generative hyphae. A little further back the thin-walled laterals of the generative hyphae are most abundant. In the pore field the skeletal hyphae of the dissepiments begin to appear and, as their production is increased along the lines of the dissepiments, they come to outnumber the rest. Nor is it till the dissepiments have been localised that their skeletals become definitely geotropic.

It is clear, therefore, that the dissepiments are formed by a special outgrowth of hyphae along certain paths, as was concluded in *P. xanthopus*, and not merely by the arrest of the general outgrowth in the pore field over certain areas which correspond with the tubes, although this process must certainly take place in the formation of the hymenium between the dissepiments. A new factor must be introduced, as a force in the pore field, to account for the localised increase in production of skeletal hyphae and for their geotropism.

### The biology of the fruit body

In July, 1930, I removed all the fruit bodies from the log on which they had been growing and let the surface dry out to ensure the development of a fresh crop on subsequent wetting. Three weeks later I had the log removed to a shady place and watered twice daily, at 8 a.m. and 1 p.m., except in rainy weather; the conditions were made as favourable as possible for the continuous growth of the fruit bodies yet without an excess of moisture. By the beginning of September the primordia began to appear as specks on the wood and four were marked down with pins to measure their rate of growth. In nine days they had become small semicircular brackets, 10 mm. in radius, and marginal growth continued uninterruptedly for the next five months by which time they had reached their full size of 7–7·3 cm. in radius and 13–13·6 cm. in width, *i.e.* the greatest length taken at right angles to the radius. The rate of growth was too slow to measure accurately the daily increment, and the following figures are derived from weekly measurements on the four fruit bodies, all of which gave nearly identical results: and to judge from several others which came up about the same time, I have no doubt that they give a fair indication.

| Size of pileus | Average rate of radial growth |
|---|---|
| 0–10 mm. in radius | *ca.* 1 mm. per 24 hours. |
| 10–32 mm. ,, | *ca.* 0·6 mm. ,, |
| 32–53 mm. ,, | *ca.* 0·4 mm. ,, |
| 53–62 mm. ,, | *ca.* 0·35 mm. ,, |
| 62–70 mm. ,, | *ca.* 0·3 mm. ,, |

The rate of growth gradually declined and by the beginning of February, 1931, it had ceased. But the brackets remained fresh and continued to form spores until the middle of April. Small tufts of hyphae then began to grow from the edges of the dissepiments and to cover the pores with a thin felt which thickened irregularly in small tubercular patches, as if a new layer of tubes was to be formed. However the fruit bodies have persisted in this state until the time of writing at the end of August. The arrest of growth must be due to internal causes, since the fruit bodies were never allowed to dry up or become too wet and there was no rotting: and the temperature followed the same daily fluctuation throughout, from 75 to 85° F., probably, in this shaded place.

A few basidia develop sterigmata as soon as the pores are delimited and the spores are matured and shed shortly afterward. Thus the young brackets begin to spore when only 2–10 mm. in radius, and the whole period of sporing in the four fruit bodies was about seven months. From December to the end of March a thin spore cloud could be seen issuing from the under side of the brackets and I have little doubt that they spored incessantly day and night.

It appears that marginal growth is intermittent and proceeds in small bursts. Some fruit bodies have broad shallow sulcations on the upper surface, which probably correspond with spells of wet weather, the margin narrowing as growth is delayed by low humidity of the air. But there are also narrow, alternating, light and dark zones in the flesh, which are slightly convex toward the margin and stretch as arcs from the upper side to the base of the tubes. In the dark zones the skeletal hyphae appear more abundant as they are closer together, and the distance from one dark zone to the next, 0·3–1 mm., corresponds with the daily increment of marginal growth. The skeletal hyphae may be produced at a definite stage in the twenty-four hours, during the night perhaps when the humidity of the air is highest, when a dark zone will be formed: and during the rest of the twenty-four hours the hyphae in growing radially separate from each other and cause the less dense, lighter zones. The phenomenon occurs in many species of *Fomes*.

Detached fruit bodies cannot withstand desiccation even for a few days. On several occasions I dried fruit bodies in the laboratory for four or five days, ten days, twenty days and thirty days, but on soaking out again they merely grew very mouldy and no basidia were found on microscopic examination. If dried off while still attached to the substratum, however, they may perhaps form a new layer of tubes, though I have not seen any specimens with this *Fomes* character.

## Discussion

A comparison between *Fomes levigatus* and *Polystictus xanthopus* is instructive, because each represents a common form of polyporoid fruit body. Some further points of construction which the study of *F. levigatus* has disclosed must also be considered.

The fruit body of all polypores must begin development as a small hemispherical primordium, and on the limitations imposed on the radial growth of this body depends the adult form. In some species with massive fruit bodies, as *F. robustus* or *P. betulinus*, the initial radial growth continues for a long time to form a large primordial knob or tubercle before the form factors come into play; mostly the radial growth is interrupted after a few days. In *P. xanthopus* the outgrowth is restricted at such an early stage over the whole surface except on the distal side where the growing-point of the primordial shaft is delimited. In *F. levigatus* the outgrowth is similarly restricted but on the upper and lower sides only, and it continues in the intermediate strip or hoop as the growing margin of the pileus. The growing-point of the primordium in *P. xanthopus* is positively phototropic and becomes diageotropic at a later stage after the formation of the pileus. In *F. levigatus* the growing margin is diageotropic from the

first and apparently never phototropic. Consequently the hemispherical primordium of *P. xanthopus* grows towards the source of light of optimum intensity as a cylindrical shaft and that of *F. levigatus* spreads out centrifugally in an equipotential plane in the gravitational field. In each it seems that the hyphae on emergence from the wood are insensitive to external stimuli and firstly, therefore, construct a hemispherical body of interwoven hyphae. On becoming phototropic or geotropic they come into alignment to form the characteristic growing regions, and by deflecting the food supply to their own ends the outgrowth from the rest of the surface is slowed down, and the specific form is gradually assumed.

The direction of marginal growth in *F. levigatus* may be exactly diageotropic at right angles to the force of gravity or slightly ascending. The degree of diageotropism varies considerably in different species but is fairly constant for any one. Some, as *F. lignosus* or *P. giganteus*, have the fruit body strongly ascending and others, as *P. amorphus*, are descending, although this feature is better displayed in some of the bracket forms of *Hydnum*.

As regards the details of the geotropic mechanism much can be learned from the manner of growth of the hyphae. From their straight course and from the fact that they form the bulk of the tissue and lead the marginal growth, it is natural to conclude that the skeletal hyphae are the sensitive elements. But whether the main generative hyphae, which grow radially in the flesh, are also geotropic cannot be decided by mere inspection, for they may follow simply the path of least resistance: the possibility is precluded, however, from their laterals which wander about. Now the set of any portion of a skeletal hypha depends solely on the direction of the apex when it traversed the region in which that portion of the hypha was laid down, because there is no motor mechanism and the walls thicken rigidly close to the apex. The geotropic mechanism must therefore reside in the apices of the hyphae. I have looked very carefully without being able to detect anything so gross as a granule, so that it must depend on microphysical forces. In *P. xanthopus* it is very precise, and the skeletal hyphae in the flesh are strictly longitudinal, but in the flesh of *F. levigatus* they are inclined to be sinuous and in the dissepiments they show most striking irregularities. As can be seen from Text-figs. 4 and 9, it is the exception rather than the rule for the skeletal hyphae to grow straight; they may deviate as much as 50° from the vertical and then gradually or abruptly return to a mean course. Yet the tubes are perpendicular. One must suppose that the mechanism is imperfectly developed here and that the set of the limb and the dissepiments is merely an average result obtained by employing a large number of hyphae. In this, perhaps, is the explanation of the unnecessary thickness of flesh and apparent waste

of substance in the fruit body of *F. levigatus*: with straight growth, and a rigid crust, a platform firm enough for the suspension of the tubes would be provided by a quarter the thickness.

Unquestionably the fruit body of *P. xanthopus* is the more highly evolved. There is greater division of labour among the hyphae; they are better organised; and the sterile tissue of the pileus is very much reduced, possibly to the minimum. *F. levigatus* has an advantage in the absence of a stem—which is scarcely necessary for the elevation of the hymenophore in an epixylous fruit body and merely delays the beginning of sporing—and, may be, in the longer tubes, but there is little to choose in this connection. The hymenium is fertile only in the lower part of the tubes in *F. levigatus*, the effective length being at most nine or ten times greater than in *P. xanthopus* (the diameter being the same in both), and the continuous production of spores is extravagantly obtained by continuously extending the hymenium through the downgrowth of the tubes. In *P. xanthopus*, the sterile tissue of the dissepiments is also reduced; the downgrowth is soon arrested, and the area of the hymenium is increased no further, but sporing continues from all parts until the decay of the fruit body through the efficient means of intercalary growth and interpolation of new basidia. Moreover the fruit body will revive after desiccation which is fatal to that of *F. levigatus*. One might boldly declare, indeed, that the *Polystictus* type is one of the most elaborate and refined of fruit bodies in the Polyporaceae.

The structural dorsiventrality of the pileus in *F. levigatus* is brought about by the generative system. If no crust or tubes were developed, both upper and lower surfaces would have the same structure. In any case the skeletal stroma, formed by marginal growth, is isobilateral, and the generative hyphae, which are equally distributed throughout, give rise at each surface, just behind the margin, to similar excrescent branches. A physiological distinction then appears. The force which generates the dissepiments is limited to the lower side, and it is only on this side that the generative hyphae, on cessation of growth, produce basidia. There is not the least sign of any such partition of outgrowth on the upper side, and the generative hyphae form the crust independently of geotropic stimuli. But the nature of this force is yet incomprehensible: it must be connected with the geotropic sensitiveness of the hyphae and it must also act at a distance, since the hyphal tips, which are not contiguous, act in unison.

Lastly, there is a point in the construction of the tubes which was overlooked in *P. xanthopus*, but is more evident in *F. levigatus* as the dissepiments are longer and thicker. The hyphal ends are arranged at the edges of the dissepiments to form growing regions similar to that at the margin of the pileus, and the growth of the hyphae on the

outside of these growing regions similarly slows down and they get left behind on the walls of the tubes. As the dissepiments remain of constant thickness, the generative hyphae must produce just sufficient new skeletal elements to replace those lost from the growing regions in this manner, or the dissepiments would grow thicker or thinner, with an irregular outline in longitudinal section, and the effectiveness of the tubes in increasing the hymenial area without interfering with the free dispersal of the spores would be much impaired. The point reveals again the remarkable precision in the minute organisation of these filamentous plants.

### Related species

The fruit bodies of the following species are constructed on exactly similar lines to that of *F. levigatus*. They differ specifically in the characters of the spores, the setae, the upper surface of the pileus, the crust, the skeletal hyphae and in the thickness of the flesh and tubes: they differ, that is, as one would expect, in the properties of the hyphal wall, in the modification of the hyphal ends on cessation of growth, in the behaviour and manner of branching of the hyphae and in the factors governing the relative development of the tissues. These are seldom recorded in specific descriptions; reliance is had rather on macroscopic characters, which are but secondary effects of the minute construction with little or no mycological significance. Differences in colour and texture are determined by the characters of the crust and the hyphal systems; the microscopic structure of the upper surface decides whether it will be smooth, matt, velutinate, tomentose, laccate, and so forth. Such descriptive terms would serve if they really indicated definite microscopic characters, but in referring only to the gross appearance they are too vague. A matt surface, for instance, may be caused by the crowding of the ends of the skeletal hyphae at a common level, by the development of an irregular crust by the generative hyphae, or merely by the excretion of granular and crystalline matter: a woody or corky texture may be due to the abundance of oblique and transverse skeletal hyphae, or to the presence of a binding system as well, or even to a single system of hyphae with thickened walls and compact arrangement. And should such fundamental differences reach a macroscopic level they can be expressed only very inadequately in degrees of woodiness, heaviness, roughness or hardness most difficult to appreciate. Hence it is almost impossible to identify a polypore with certainty from the customary descriptions; a thorough microscopic examination will so often disclose constant peculiar details in otherwise similar fungi that the type material must be re-examined to decide the issue. The published descriptions of all the following apply equally well to *F. levigatus*, so that, in the absence of type material, I can merely set forth in a preliminary manner the

results of microscopic examination of the authentically named specimens in the Singapore herbarium, and trust that they will be checked over in time by reference to the types.

The Polyporaceae are acknowledged among the most perplexing fungi to identify. The reason is surely because their detailed study has scarcely begun: only by carrying the microscope to all points can one try out the limitations of a morphological classification.

*Fomes senex* (Nees et Mont.) Fr.

Material:

Sing. F. No. 5387. Singapore, det. C. G. Lloyd.
Sing. F. No. 5867. Singapore, det. C. G. Lloyd.
Sing. F. No. 5853. Johore, det. C. G. Lloyd.
Sing. F. No. 8390. Singapore, det. C. G. Lloyd.

This species differs from *F. levigatus* in the following points:

(1) At the upper surface of the pileus the skeletal hyphae are arranged in a fairly regular pile with their ends free or only slightly agglutinated and projecting perpendicularly or obliquely forward. There is no crust, or only a thin (5–10 $\mu$), structureless, hyaline, interrupted layer above the pile (Text-fig. 10).

(2) The skeletal hyphae are light yellow, rather narrower, (2–3·5 $\mu$ wide, rarely 4 $\mu$), and those of the dissepiments are very much straighter.

(3) The flesh is relatively thinner (1–5 mm. thick at the base of the pileus, though up to 12 mm. thick if there is a basal pad, and 0·5–2 mm. at 5 mm. from the margin), and the tubes in fruit bodies of the first season are much longer (up to 6 mm. long at the base) (Text-fig. 6).

(4) The spores have a large median or basal gutta, 2–2·5 $\mu$ wide (Text-fig. 11). Such a difference appears trivial though it is constant nevertheless.

(5) The setae are rather larger, 18–30 × 5–7 $\mu$, rarely up to 36 × 7–8 $\mu$ (Text-fig. 11).

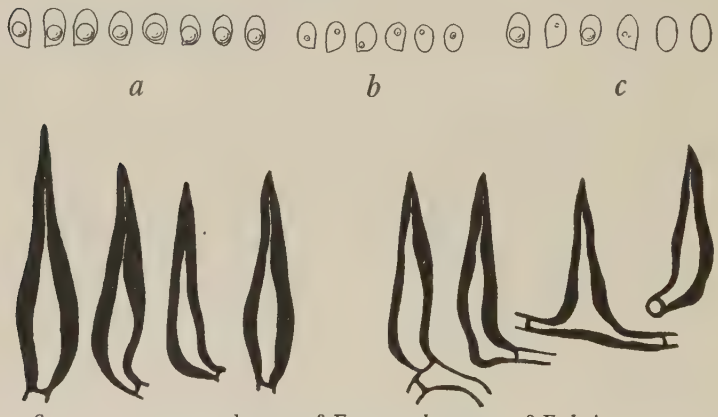
(6) The cystidia are very sparse.

Moreover, the fruit body is very variable in shape and grows to a large size. Typically it is bracket-shaped, but it is often widely effuso-reflexed and occasionally wholly resupinate like a *Poria*, and it may be perennial, the tubes developing up to 6 cm. long in indistinct layers 1–3 mm. thick. The largest Malayan specimen as yet discovered measures 27·5 cm. in radius and 45 cm. wide. It is also very common, perhaps the commonest *Fomes* in the country, and occurs at all altitudes up to 6000 ft.

To the naked eye fruit bodies of *F. senex* are distinguished by a roughish or velutinate, dull and narrowly sulcate upper surface, the thinner and much paler, cinnamon-tawny or tawny-ochraceous flesh

and the longer tubes. A comparison of specimens of both species side by side enables one to separate those of *F. levigatus* at a glance by the smooth, unpolished surface and the deep brown flesh.

Text-fig. 10. A part of the upper surface of the fruit body of *F. senex* taken near the base. × 500.




Text-fig. 11. *a*, spores and setae of *F. senex*; *b*, spores of *F. levigatus*; *c*, spores and setae of *Polyporus gilvus* var. *licnoides*. × 1000.

Concerning the colour of the spores there appears some misunderstanding. Lloyd says that they are yellow-brown and are rather scanty and often absent from herbarium specimens. I have obtained spore prints from fruit bodies of several different collections and they

are always pure white: the fresh spores are colourless, 3·5–5 × 2·5–3 μ, and shaped as in *F. levigatus*. On the other hand, old spores lying in the tubes in these fruit bodies had pale yellow walls and some of the basidia in the effete portions of the tubes had contracted into small subglobose bodies, 3–5 μ wide, with thick yellow-brown walls remarkably like the spores of *F. rimosus*. The fruit bodies were identical with the authentically named material, wherefore it must be concluded that *F. senex* has white spores.

Although a crust does not develop on the upper surface, there is a slight outgrowth of generative hyphae just behind the margin similar to that in *F. levigatus*. The colourless processes from the generative hyphae may project up to 12 μ and be so numerous and lobed as to form a loose covering over the surface about 5 mm. from the margin, but as they do not become thick-walled they soon wither away and leave the ends of the skeletal hyphae free or slightly agglutinated in their structureless remains, in which foreign spores and bacteria may then begin to grow.

I have tested their ability to resist desiccation on several occasions, but the fruit bodies are no better equipped than those of *F. levigatus* and survive not even a few days.

On the form of the setae two varieties can be distinguished as follows:

var. *hamatus* var.nov. Text-fig. 12.

Setis majoribus, apicibus plerumque curvatis vel hamatis, 26–35 × 5–8·5 μ.

Loc. Pahang, 6000 ft.: Pahang, 4000 ft. (parasitic at the base of a large tree): Negri Sembilan, 2300 ft.: Penang, sea-level, Sing. F. No. 5597: Singapore, 400 ft., Sing. F. No. 5098.

While most of the setae are characteristically hooked, some are merely flexuous and a few are of the straight conical kind. I have examined some hundred fruit bodies of typical *F. senex*, however, and have not seen one which had such strongly curved setae.

The specimens from Pahang were very large, thick *Fomes* forms; those from Negri Sembilan were medium sized; those from Singapore were small and polyporoid; and that from Penang was small and effuso-reflexed.

var. *bulbosetosus* var.nov. Text-fig. 12.

Setis multo majoribus, valde ventricosis, apicibus plerumque hamatis, 20–40 × 7–15 μ.

Loc. Endau River, Johore, Sing. F. No. 24875.

This variety is founded on a single collection of typical medium-sized fruit bodies with one or two layers of tubes, made by the Director of the Singapore Botanic Gardens. The setae are, however, most characteristic and very few of the ordinary kind occur.

*Fomes zelandicus* Cke.

Cunningham has described this species in detail from New Zealand (*Trans. N.Z. Instit.* LVIII (1927), 213).

It is a question whether it is not *F. senex*. Specimens sent abroad for determination were referred to that species, but as Lloyd had ascribed coloured spores to *F. senex* and those of the New Zealand specimens were white, Cunningham retained Cooke's name for them.

Text-fig. 12. Setae of *F. senex* var. *hamatus* above and of var. *bulbosetosus* below. × 1000.

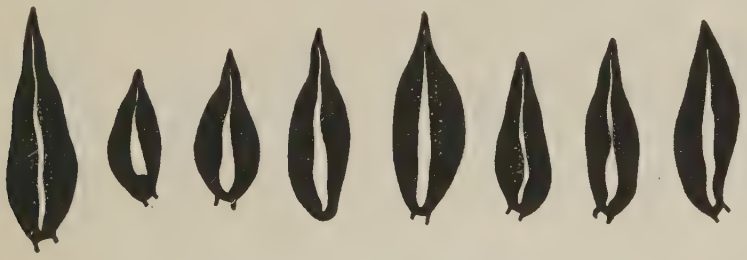
His description of *F. zelandicus* applies so exactly to the Malayan specimens also that they are surely the same species, though I have not examined material of the former. As I have just shown, the yellow-brown colour of spores in *F. senex* is probably a post-mortem effect and they are colourless when fresh. Alternatively, *F. senex* is another species with truly coloured spores, as the type came from Chili and the Malayan and New Zealand specimens are wrongly referred to it. It will be necessary to re-examine the type.

*Fomes velutinosus* Hutchings, Lloyd, *Syn. Fom.* 1915, 260.

Material:

Sing. F. No. 8786. Pahang, det. C. G. Lloyd.

Lloyd (Letter 48, note 110) says that this species differs from *F. senex* in the much smoother surface which often has a banded effect (as in *Polyporus gilvus* var. *licnoides*), the softer, well-developed context and, especially, in the strongly velutinate, deeper coloured pores. He says that it may be the *Polyporus* form of *F. senex* since all the specimens have only one layer of tubes, and later (Letter 66, note 642) calls it *Polyporus velutinosus*. The diagnostic characters suggest *F. levigatus*, but Sing. F. No. 8786 is typical of *F. senex* in the first season with a single layer of tubes. It seems therefore that *F. velutinosus* is synonymous with *F. senex*. Every *Fomes* is a *Polyporus* at the outset, and dark velutinate pores are characteristic of the growing dissepiments of *F. senex* as of most other brown species.



Text-fig. 13. Setae of *F. extensus*. × 1000.

*Fomes extensus* Lév.

Material:

Sing. F. No. 10890. Johore, det. C. G. Lloyd.
Sing. F. No. 18665. Borneo, det. E. M. Wakefield.

Except for slight differences in shape the specimens in these two collections are identical. The species can be distinguished readily from *F. senex*, to which it is closely allied, by the following points:

(1) There is a hard black crust, 300–500 $\mu$ thick, just beneath the upper surface of the pileus. The ends of the skeletal hyphae project freely for a distance of 100–400 $\mu$ beyond the crust in a close pile.

(2) The setae are stouter with very thick dark brown walls, 20–35 × 6–10 $\mu$ (Text-fig. 13).

(3) Possibly the flesh is thicker (7–11 mm. thick at the base, 3–4·5 mm. at 5 mm. from the margin).

Macroscopically it can be distinguished from *F. senex* and *F. levigatus* by the hard, rigid, finely villose surface. It is superficially very like *F. lamaensis*.

The crust is formed, as in *F. levigatus*, from branches of the generative hyphae which interweave among the skeletals but beneath the surface, and they acquire thick, dark brown, resinaceous or carbonaceous walls on becoming agglutinated. Before the crust develops the structure of the upper surface is the same as in *F. senex*. It is noteworthy that occasionally fruit bodies of *F. senex* have a very thin, black, crustaceous line, 50 $\mu$ thick, near the base of the pileus, about 1 mm. below the surface, and composed of similar resinaceous generative hyphae.

I did not find spores, but Bresadola gives them as subglobose, yellow-brown, 3–4 $\mu$ (*Ann. Myc.* XIV (1916), 236): but conceivably the fresh spores are white also. The skeletal hyphae are narrow, 2–3·5 $\mu$ wide, seldom 4 $\mu$.

The species is evidently rare in Malaya and Lloyd mentions having seen besides Sing. F. No. 10890 only the type collection from Guadeloupe.

*Polyporus gilvus* (Fr.) Schw.

Material:

No. 5831, ex herb. J. Weir, Indiana, N. Am., det. J. Weir.

This species can readily be told from the foregoing by the hyphal organisation which is advanced but little beyond the monomitic state. The generative hyphae are very abundant and conspicuous and form the greater part of the flesh; they have the same characters as in *F. levigatus* but are more inclined to be thick-walled (0·5–1 $\mu$ thick). The skeletal hyphae, which are 3–6 $\mu$ wide, rarely 7 $\mu$, are distinctly in the minority, and, while being unbranched with thickened, light golden yellow walls (0·5–2 $\mu$ thick), they retain a *wide septate lumen*: only occasionally in the oldest tissue at the base of the fruit body the lumen is reduced to a line. The septa are spaced 25–180 $\mu$ apart and frequently are slightly convex forwards. Mediate hyphae are hardly recognisable. The hyphae are mostly radial and loosely arranged: consequently the flesh has a light fibrillose texture, scarcely woody, and a bright tawny yellow colour: and owing to their wide lumen most of the hyphae collapse on drying.

On the other hand the skeletal hyphae of the dissepiments are well differentiated with the same characters as in *F. levigatus* and the tubes have the same compact structure.

A crust also develops on the upper side of the pileus in the same way as in *F. levigatus*; it may reach 60 $\mu$ thick at the base of the pileus, though usually it is 10–20 $\mu$ thick, and there is no regular pile such as in *F. senex*. The upper surface appears therefore smoothed over with a dull finish.

The small, granular, substrigose or subtuberculate excrescences near the base of the pileus, which are conspicuous in the variety

*Hookeri* (= *P. Hookeri* Berk.) are formed by the outgrowth of narrow skeletal hyphae having the same characters as those of the dissepiments: they arise evidently in the same manner, from branches of the generative hyphae at the surface, and grow out irregularly, intertwining with others, and are covered by the crust on cessation of growth: sometimes they do not penetrate the original crust which is therefore just raised in small bulges. The excrescences are without order, scattered or crowded, unlike the dissepiments, and they do not begin to develop until the margin has advanced a distance of 1–2 cm. Nevertheless it is interesting to find a comparable behaviour in the generative hyphae on both sides of the pileus, for it is well known that when a branch or log bearing polyporaceous fruit bodies is turned upside down tubes will then develop from the original upper side.

Typical specimens of *P. gilvus* have not been found in Malaya, all the collections being referred to the following variety.

var. *licnoides* (Mont.) Lloyd.

Material:

Sing. F. No. 5136. Singapore, det. C. G. Lloyd.
Sing. F. No. 8460. Pahang, det. C. G. Lloyd.
(*Fungi Malay*, C. F. Baker, No. 384, det. N. Patouillard is *F. senex*.)
(Sing. F. No. 5098, det. C. G. Lloyd is *F. senex*.)

This variety is distinguished by the thin flesh (1–4·5 mm. thick at the base of the pileus, 0·3–0·5 mm. at 5 mm. from the margin), the shorter tubes (1–2·5 mm. long at the base, 0·5–1·5 mm. at 5 mm. from the margin), the reddish brown zones on the pileus and the fact that it occurs only in tropical or subtropical countries, while *P. gilvus* extends to the temperate regions. Microscopically it is identical with *P. gilvus*, though the crust is but very slightly developed. It seems not uncommon in Malaya. The spores, basidia and setae are exactly as in *F. senex* only the setae are a trifle narrower (4–6 $\mu$ wide), and the gutta in the spore varies much in size (0·5–2 $\mu$) and may even be absent; the cystidia are as numerous as in *F. levigatus*.

var. *scruposus* (Fr.) (= *P. scruposus* Fr.).

Material:

Sing. F. No. 5772. Singapore, det. C. G. Lloyd.

These specimens have the same shape and hyphal characters as *P. gilvus*, but the structure of the upper surface is decidedly different. It is like that of *F. senex* only the skeletal hyphae project freely to a much greater distance in more or less discrete fascicles to give a strigoso-fibrillose (neither tuberculate nor granular) appearance: nor is there a crust. The fascicles are formed by the main skeletal hyphae of the flesh which continue to grow out though they fall behind the margin, and not, as in *P. gilvus*, in a secondary manner

from superficial generative hyphae. So, if this collection be correctly named, the superficial outgrowths of var. *scruposus* differ in origin from those of var. *Hookeri*, and the former bears the same relation to *P. gilvus* in this respect as *F. senex* does to *F. levigatus*: it may prove specifically distinct.

*Polyporus carneofulvus* Berk.

Material:

Sing. F. No. 5619. Penang, det. C. G. Lloyd.

This collection is *F. levigatus*. *P. carneofulvus* is stated to be a synonym or merely a variety of *P. gilvus*, and if so should have the same hyphal characters: those of Sing. F. No. 5619, however, are identical with *F. levigatus*. The problem thus arises whether Lloyd was correct in this determination, in which case *F. levigatus* becomes a synonym of *P. carneofulvus* and *P. carneofulvus* a distinct species: but reference must be made to the type.

*Polyporus biogilvus* Lloyd.

Material:

Sing. F. No. 5092. Singapore, det. C. G. Lloyd.
Sing. F. No. 23720. Singapore, det. E. M. Wakefield.

Lloyd described this species from an African collection and remarked that it differed from *Polyporus gilvus* in context, absence of setae and spores (*Myc. Notes*, LXII (1920), 943). On the label of Sing. F. No. 5092 he wrote: "It is *gilvus* without setae."

Both collections are of the same species. The fruit bodies are trimitic with conspicuous binding hyphae, like *P. xanthopus*, but I have not been able to determine exactly the nature of the generative system. The skeletal hyphae have mostly a wide lumen with but slightly thickened walls.

The species is not nearly related to *P. gilvus*, however much alike superficially. As Miss Wakefield remarked on the label of Sing. F. No. 23720, "it is better as *Polystictus*."

The following species may also belong to the *gilvus* alliance, but there is no material of them in the Singapore herbarium: *Polyporus chrysellus* Bres., *P. intactilis* Lloyd, *P. multisetosus* Lloyd, *P. pseudogilvus* Lloyd, *P. Ramosii* Lloyd, and *P. subgilvus* Bres. Lloyd also describes as *Fomes gilvus* some indurated, perennial specimens from several tropical countries, and implies that they are merely perennial forms of *P. gilvus*. That they have a hard consistency throws doubt on the suggestion, since the flesh of *P. gilvus* is essentially light and fibrillosely woody on account of the peculiar hyphal characters: indurated flesh probably means abundant very thick-walled skeletal hyphae and such forms must belong rather to *F. senex* or *F. levigatus*. As already mentioned, both Patouillard and Lloyd mistook specimens of *F. senex* for *P. gilvus* or its varieties.

Summary

The structure, development and biology of the fruit body of *Fomes levigatus* n.sp. are described, with a specific diagnosis.

The fruit body is a diageotropic bracket composed of aseptate, unbranched, thick-walled, skeletal hyphae and septate, branched and thin-walled generative hyphae; binding hyphae are absent; the generative hyphae are not clamped.

The development of the dissepiments from the generative system is described in detail. The skeletal hyphae of the dissepiments do not become positively geotropic till some time after their origin in the pore field.

Radial growth of the bracket is slow with an initial rate of about 1 mm. per 24 hours gradually falling off to zero. In the fruit bodies studied, marginal growth continued for five months: sporing began when the primordia were 2–10 mm. in radius and lasted for seven months. Basidia begin to mature almost immediately after the pores are delimited but only the lower parts of the tubes, for $\frac{1}{2}$–1 mm. from the pores, are fertile in matured fruit bodies: the upper parts are lined with effete hymenium and stuffed with hyphae derived from the mycelium. Continuous sporing is obtained by the continuous development of new hymenium through the downgrowth of the dissepiments.

The fruit bodies cannot survive desiccation. Perennial specimens have not been collected.

Comparison is made with the fruit body of *Polystictus xanthopus*. The *Polystictus* type is considered the more highly evolved on account of the greater division of labour among the hyphae, the more precise organisation, the continuance of sporing by means of persistent intercalary growth of the hymenium (thus dispensing with long tubes), and the ability to resist desiccation.

The distinctive characters of related species, especially of *F. senex*, *F. extensus*, and *Polyporus gilvus*, are enumerated. They have the same systems of hyphae as *F. levigatus*, but the skeletal hyphae in the flesh of *P. gilvus* are poorly differentiated, retaining a wide, septate lumen, and are much less numerous than the generative hyphae. *Polyporus biogilvus* is not nearly related, having three systems of hyphae like *P. xanthopus*.

*Fomes velutinosus* and *F. zelandicus* are considered synonyms of *F. senex*.

Two new varieties of *F. senex* are proposed on the form of the setae, namely var. *hamatus* and var. *bulbosetosus*.

The terms *dimitic* and *trimitic* are proposed for fruit bodies composed of two and three systems of hyphae; *monomitic* for those of one system.

# NOTES ON BRITISH AQUATIC FUNGI

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(With 6 Text-figures)

Many genera of aquatic fungi are common to Europe and to North America, and they are represented in the two continents either by the same or by closely related species. Records of aquatic fungi in the British Isles are relatively scanty, as may be seen from the list given by Ramsbottom (28). This apparent absence of widely distributed forms led the senior author to conjecture that such forms could be found in this country if looked for, and this is being done. In connection with this search, endeavours have been made, with some success, to apply the methods introduced by Harvey (9), and pursued by Coker and others (3, 4), to an investigation of the phycomycetous flora of the soil of a garden in South London. The present note is a preliminary report of the results of a not very extensive search: the results suggest that further work of the kind may be well worth the doing.

Several interesting fungi have already been found. From the garden soil, *Thraustotheca clavata* (40) was isolated in the autumn of 1929. In place of the boiled hemp seeds recommended by Harvey (9), boiled cress seeds have been used, as they seem less liable to bacterial infection: on this substratum the fungus has since flourished in culture. The same soil has yielded a species of *Geolegnia*, a genus hitherto reported only from North America (9).

In the same garden, pots of water containing rotting leaves have been examined from time to time, and, from these pots, *Zoophagus insidians* (31, 33, 39), *Lagenidium Syncytiorum* (13) or a closely allied species, and the peculiar Hyphomycete *Tetracladium Marchalianum* (42, 43) have been obtained, though only in small amounts.

In 1929, Miss Weiste (now Mrs Barnard), made a few experiments in a garden in North Kent. She floated small fruits in a pond, a method already used by von Minden (25) and by Kanouse (10, 11, 12): bacterial contamination was heavy, but, from the slime, *Pythiomorpha gonapodioides* (26, 27, 10, 12) was isolated. This work came to an end before much had been done, as Miss Weiste accepted an appointment in Burma.

None of the fungi mentioned above appears to have been previously recorded in Britain. In the present work, only *Thraustotheca clavata* has been grown satisfactorily in pure culture.

On October 19th, 1930, the junior author collected some mouldy twigs from a pond at Forest Row. These twigs were densely covered by *Dictyuchus monosporus*: washings from the twigs contained an abundance of such Protozoa as *Spirostomum*, *Stentor* and *Arcella*. The fungal covering was thoroughly sampled. *Dictyuchus* was very abundant: one sample yielded a very small tuft of *Monoblepharis sphaerica*, another gave a few poor scraps of *Gonapodya siliquaeformis*, and a third contained badly developed specimens of a species of *Blastocladia*. On April 12th, 1931, a twig taken from water at Elstree was found to be thickly overgrown by a species of *Achlya*, together with a good deal of *Monoblepharis polymorpha*: *Apodachlya pirifera* was present, but *Dictyuchus* was not found; the protozoan associates were not identified. Another twig, collected on May 10th, 1931, from the pond at Forest Row, bore an old growth of *Dictyuchus*, covered with epiphytes and possibly dating from the previous autumn, some *Apodachlya pirifera*, and plenty of *Monoblepharis polymorpha*. *Arcella* was present, but *Spirostomum* and *Stentor* were not seen.

These three collections of mouldy twigs have yielded three genera, *Monoblepharis*, *Gonapodya* and *Blastocladia*, all new to this country. It is of interest that *Monoblepharis polymorpha* was found in two localities, forty miles apart.

Up to the present, it has not been possible to get any of these fungi into pure culture: attempts are still in progress. The following notes are based on observations made on the material soon after it had been collected, or after it had been in the laboratory for a short time.

### *Monoblepharis*

Very thorough accounts of species of *Monoblepharis* have been published by several authors (6, 7, 17, 18, 19, 34, 37, 44) and, as these are printed in readily accessible publications, it is unnecessary to give a detailed treatment of the genus here. A few matters, however, need brief mention. The peculiar straight-sided vacuoles which occur in the hyphae have been described by several authors who have examined *Monoblepharis* and they afforded a ready means of identifying vegetative hyphae of the matter dealt with here. The oospores, studded when ripe with hemispherical warts, are very conspicuous, and when present, are a sure means of recognising the fungus.

The distribution of the genus is of interest: it is believed that all previous records appear in Table I.

The table shows that the species of *Monoblepharis* have been found only in a relatively limited portion of the North Temperate Zone; further records are much to be desired. It still remains to be shown if *Monoblepharis* is a cold-weather form in this country: we have never found it on twigs gathered in July and August. If there is a temperature relation, that may account for the general northerly distribution, but

it appears likely that extended search will greatly enlarge the area in which the genus is known to occur.

Table I. *Distribution of* Monoblepharis

| Author | Date | Locality | Species: *sphaerica* | *polymorpha* | *macrandra* | *brachyandra* | *insignis* | *fasciculata* | *ovigera* | *regignens* |
|---|---|---|---|---|---|---|---|---|---|---|
| Cornu (6) | 1871 | France | × | × | – | – | – | – | – | – |
| Massee (22) | 1891 | Britain* | × | – | – | – | – | – | – | – |
| Thaxter (34) | 1895 | N. America | – | × | – | – | × | × | – | – |
| de Lagerheim (17) | 1900 | Sweden | – | – | × | × | – | – | × | × |
| von Minden (23) | 1902 | Germany | – | × | – | – | – | – | – | – |
| Thaxter (37) | 1903 | N. America | – | – | – | × | – | – | – | ? |
| Woronin (44) | 1904 | Finland | × | × | × | – | – | – | – | – |
| Petersen (26) | 1909 | Denmark | – | – | × | × | – | – | – | – |
| Claussen (1) | 1912 | Germany | – | – | – | ×† | – | – | – | – |
| von Minden (24) | 1912 | Germany | – | – | × | – | – | – | – | – |
| von Tieşenhausen (38) | 1912 | Switzerland | – | × | × | – | – | – | – | – |
| von Wettstein (41) | 1921 | Austria‡ | – | × | × | – | – | – | – | – |
| Laibach (18) | 1926 | Germany | × | × | × | – | – | – | – | × |
| Scherffel (30) | 1931 | Hungary | – | – | ? | – | – | – | – | – |
| | | Totals | 4 | 7 | 8 | 4 | 1 | 1 | 1 | 3 |

× = record. ? = doubtful naming. – = no record.

* This record is discussed below.
† The specific name is taken from von Minden, 1912.
‡ Locality not stated, here assumed to be Austria.
The dates given are the dates of publication, and not necessarily of collection.

In the present study, two species, *Monoblepharis sphaerica* and *M. polymorpha*, have been found.

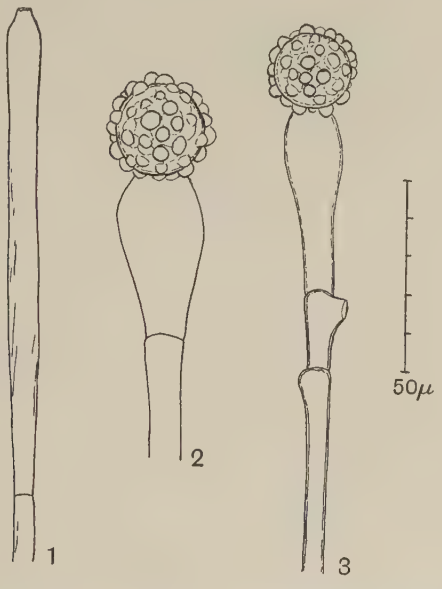
### *Monoblepharis sphaerica* Cornu (6, 7)

A very small amount of material regarded as belonging to this species was found on the twig collected at Forest Row in the autumn of 1930. There were a few vegetative hyphae showing the characteristic vacuolisation, a long cylindrical structure interpreted as an empty zoosporangium, and a few groups of sexual organs: three hyphae ended in solitary oogonia each with a hypogynous antheridium, five ended each in one oogonium, and one bore a terminal series of two oogonia. Zoospores and sperms were not seen, and all the oospores were mature and lay attached to the outside of the mouths of their respective oogonia. The ten oospores, measured in water, averaged 25·2 $\mu$ in diameter: the largest measured 28·6 $\mu$, the smallest 20·8 $\mu$.

The hypogynous antheridia, the rather large oospores, and the characters of the presumed zoosporangium, all indicate that the

material belonged to *M. sphaerica*: it is hoped that a further gathering will make possible a confirmation of this identification.

*M. sphaerica* was included among British Phycomycetes by Massee (22), but an examination of his statements and figures leaves the impression that the record cannot be accepted. The description is clearly taken from Cornu (7). The habit-drawing given by Massee seems certainly to be a rough copy of Cornu's habit-drawing, and his other figure, showing emergence of the sperms and entry into the oogonium, is apparently one of Cornu's figures, modified and turned through




Text-fig. 1. *Monoblepharis sphaerica* Cornu. 1. An empty zoosporangium. 2. An empty oogonium surmounted by a mature oospore. 3. Oospore, oogonium and empty, hypogynous antheridium.

180°. Massee does not figure the oospores, which are usually the first objects to attract the eye of the observer. Massee's figures could hardly have been prepared by one who had seen the fungus.

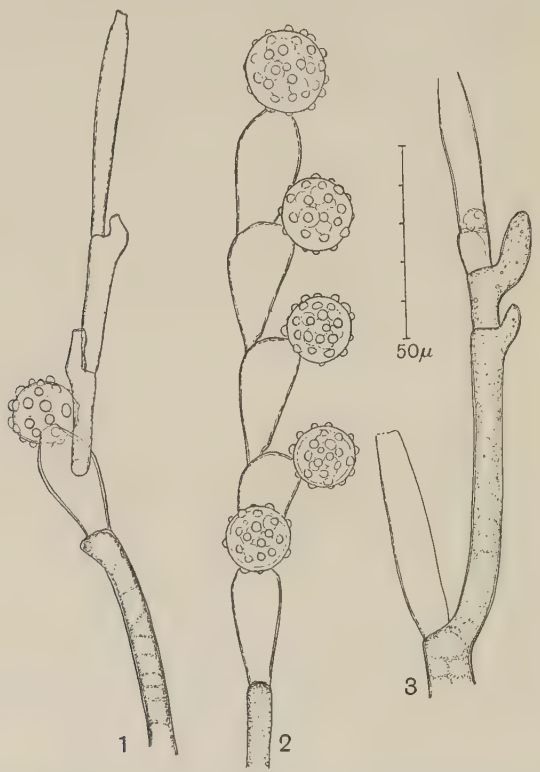
It is well known that Cornu's description of *Monoblepharis* aroused great interest among mycologists, and that the fungus was searched for without success, so that a general hesitation to accept Cornu's statements had grown up. If Massee had found *Monoblepharis*, or if he had a reliable record of it having been found by someone else, it seems very improbable that he would have omitted to have given the name of the finder and of the locality, and that he would have dismissed this interesting fungus in the very brief way he does. It may be significant also, that Massee's record is not referred to by any of

the European and American students of the genus: there is general agreement that Thaxter, in 1895, was the next, after Cornu, to find *Monoblepharis*.

It appears, therefore, that the inclusion of *Monoblepharis* in the British fungous flora by Massee cannot be accepted. The present record, based unfortunately on very little material, seems to be the first we have.

*Monoblepharis polymorpha* Cornu (6, 7)

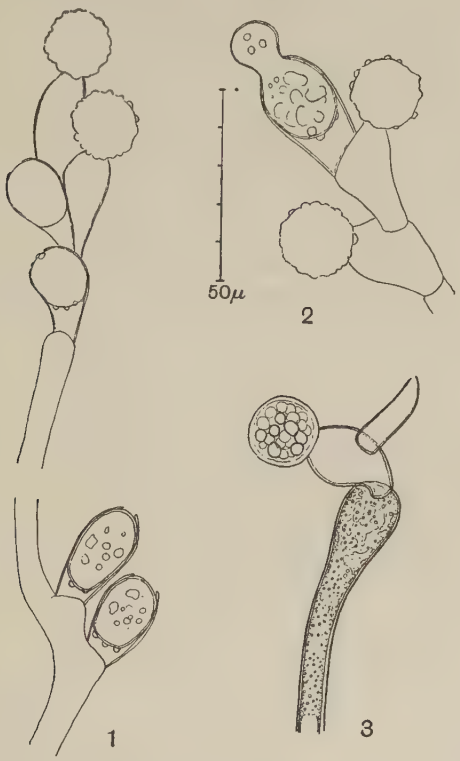
*M. polymorpha*, a species not previously recorded from Britain, was obtained twice in the spring of 1931, once from Elstree, and once from Forest Row. As material was relatively plentiful, it was possible to make a thorough examination: the descriptions given by previous




Text-fig. 2. *Monoblepharis polymorpha* Cornu. 1. A chain of three empty antheridia surmounting an empty oogonium with a mature oospore lying outside the mouth. 2. A chain of five empty oogonia, each with a mature oospore lying outside the mouth. 3. An antheridial branch, with two empty antheridia and two in course of formation. The uppermost antheridium contains a non-emerged sperm lying on a fold in the wall. The characteristic vacuolisation is shown in figures 1 and 3.

authors have been confirmed, and, in one important respect, extended.

The material of *Monoblepharis* found in the spring of 1931, has been named *M. polymorpha* (Text-figs. 2 and 3). Some difficulty was experienced in arriving at a specific name, for, while there were obvious characters which ruled out *M. sphaerica*, it was not at first clear




Text-fig. 3. *Monoblepharis polymorpha* Cornu. 1. Portion of a fertile branch: in four of the oogonia, oospores have completed development without emerging. 2. Group of three oogonia: in one, a partly emerged but mature oospore is present. 3. A young, fully emerged oospore before the formation of the warted wall: the epigynous antheridium is clearly shown.

if we were dealing with one species, namely *M. polymorpha*, or with a mixture of this species and *M. macrandra* (17, 44, 24). It seems, however, that it is best to apply the name *M. polymorpha* to the material, because no evidence was obtained that any of it showed features which seem to be distinctive of *M. macrandra*, namely, a capacity of the oospores to mature quite free from the parent plant, and a tendency of the oogonia to crumple after the oospores have quitted them.

Branches bearing oogonia alone, and others bearing antheridia alone were found. These conditions may occur in both *M. polymorpha* and *M. macrandra*, though perhaps most often in the latter. Quite as frequently, however, groups including antheridia and oogonia were encountered. Indeed, on the general question, a little scepticism on the distinctness of the two species, *M. polymorpha* and *M. macrandra*, may be permitted. As Table I shows, these are the species which have been most often recorded, and they have often been found together. It is well known that the morphology of aquatic fungi can be profoundly affected by the conditions under which the fungi are growing (2, 5, 20, 21), so much so that not merely specific, but even generic limits may be transgressed. Until *M. polymorpha* and *M. macrandra* have been shown to retain their characters when grown in pure culture under comparable conditions, some doubts must remain of the distinctness of these species.

As ripe oospores were abundant, the diameters of 500 were measured in water: the diameters include the warts. The measurements are given in Table II.

Table II. *Diameter of oospores of* Monoblepharis polymorpha

| Diameter in arbitrary units | No. of oospores | Diameter in arbitrary units | No. of oospores |
|---|---|---|---|
| 5·5 | 5 | 8·0 | 112 |
| 6·0 | 25 | 8·5 | 50 |
| 6·5 | 57 | 9·0 | 34 |
| 7·0 | 79 | 9·5 | 12 |
| 7·5 | 123 | 10·0 | 3 |

Value of unit = 2·625$\mu$

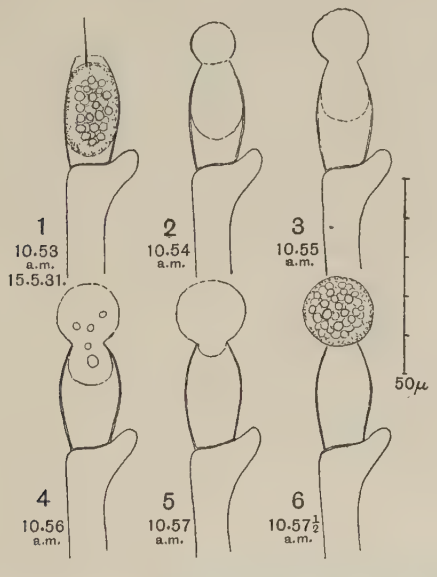
| | |
|---|---|
| Diameter of smallest oospores: | 14·4$\mu$ |
| Average diameter of oospores: | 19·9$\mu$ |
| Diameter of largest oospores: | 26·25$\mu$ |

The results of these measurements give a very uniform normal frequency curve and they support the view that the material examined was homogeneous in character.

Although material was plentiful, most of it was rather old, and young growths did not develop well under laboratory conditions. However, active material was found one morning in the sample from Forest Row. The union of the gametes was watched in eight specimens, and two series of drawings were made.

The first observation was made on a terminal oogonium (Text-fig. 4). The oogonium showed a widely open apical pore, and contained an oosphere which had contracted somewhat from the base and apex of the oogonium. The body of the sperm was already fused with that of the oosphere, from the distal end of which the cilium of the sperm stood stiffly out. Faint streaming motions were visible

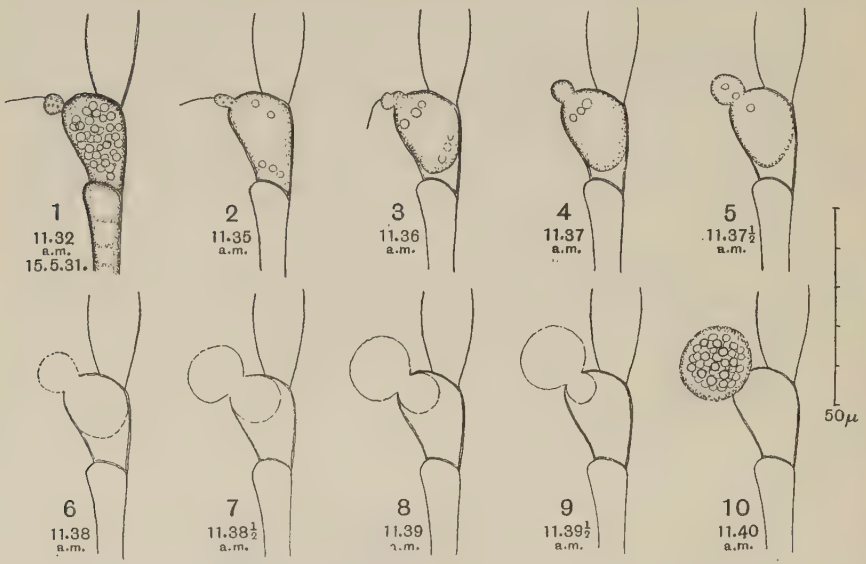
in the fusion body. Apart from these movements, no change was seen for five minutes, when the hitherto stiff cilium suddenly disappeared, and the body began to move forward in a steady streaming motion. There was no preliminary retreat towards the base of the oogonium (17) and indications of amoeboid movement were not detected. Once motion had begun, it continued evenly and steadily in a forward direction until the whole mass had passed to the outside of the oogonium, and rounded off. The contained oil drops passed through the pore without change of form. The migration was completed in four and a half minutes.




Text-fig. 4. *Monoblepharis polymorpha* Cornu. Fertilisation and emergence of the oospore. The times are given for each stage drawn. The contents are fully drawn in 1 and 6 only. (For description see text.)

Two minutes after migration had started, a couple of sperms approached the emerging egg, and they spent about two minutes exploring its surface. They did not creep upon it, but swam in the immediate neighbourhood, and butted persistently at the emerging body: they seemed to pay special attention to the constriction caused by the pore in the oogonium. Finally, when emergence was nearly complete, both swam out of the field of view, neglecting a nubile oogonium close by, although one of them had touched this oogonium from time to time as it butted against the emerging egg. The oogonium so disregarded was subsequently entered, after the proceedings just described had come to an end.

The second specimen which was drawn (Text-fig. 5) showed a point of special interest. An oogonium was selected for observation, which, from its appearance, seemed to be mature. It was completely filled with granular material, including many moderately large oil drops: faint streaming could be detected by movements of the granules. For some minutes, although sperms were fairly numerous, nothing was seen to occur. Sperms swam past the oogonium, but none alighted on it. Then one came into the field of view, swimming in a steady fashion: it suddenly stopped, changed direction, and, by a rapid swoop, alighted on the apex of the oogonium. The cilium now




Text-fig. 5. *Monoblepharis polymorpha* Cornu. Fertilisation and emergence of the oospore. The times are given for each stage drawn. (For description see text.)

stuck out stiffly behind, and moved hardly at all. Faint streamings continued inside the oogonium, and very faint movements were perceptible within the sperm. At the time when the sperm alighted, there was no papilla on the oogonium, and an open pore could not be seen. Attempts were made to determine the manner in which perforation of the wall of the oogonium was brought about, but, although careful adjustments of illumination were made, the mode of perforation could not be exactly followed. Material was not seen to exude from the oogonium, either before the sperm settled, or subsequently, before entry began. There seems little doubt that the wall of the oogonium was unperforated at the time when the sperm alighted on it. Three minutes after the sperm settled, entry was in

progress. The body of the sperm was now much narrower, and a boundary could not be seen between the granular material of the bodies of the uniting gametes. Clearly, there was now a pore in the oogonial wall. A little later, the body of the oosphere contracted away from the basal wall of the oogonium, and internal streaming became more vigorous. Four minutes after the sperm had settled, granular material began suddenly to emerge from the pore, and the body of the sperm was pushed to one side. The streaming in the general body of the oosphere was continuous with that in the bulge, and, once the bulge had appeared, the outward migration of the egg went on steadily and without interruption. These observations, and the lateral displacement of the sperm as the bulge formed, suggest that the latter was formed by some activity of the oosphere, and that the development of the bulge was not merely a mechanical effect due to passive displacement of the substance of the oosphere by the entering sperm.

Soon after the bulge formed, the cilium of the sperm suddenly disappeared, and, five minutes after the sperm had settled on the oogonium, its body had fused completely with the protuberance from the oosphere. From this stage the steady emergence of the egg continued, and all was out and rounded off eight minutes after observations began.

The six other specimens observed agreed in their general behaviour with the first described. None of them showed any indication of the migration of the oosphere before fusion was complete. In each, the process was watched from the settling of the sperm to complete emergence: the average time taken was eight and a half minutes. In none was the time necessary for the formation of the fully sculptured wall determined; this process apparently demands several hours for completion.

A few comments of a general nature are suggested by these observations.

(1) *Attraction of the sperms.* In the material examined the nubile oogonia did not seem to be specially attractive to sperms. There was no evidence of the exudation of attractive material, and sperms were seen to touch and to disregard oogonia, which, to all appearance, were ripe: the bacteria present showed no tendency to collect around ripe oogonia. The attentions paid to an emerging egg by sperms, suggest however that, at that time, substances attractive to sperms are present. When sperms were seen to alight, they did so by a sudden and very definite movement, and this may indicate that an attractive substance is present in the water, only in the immediate vicinity of the oogonium and, possibly, only for a limited time.

(2) *Perforation of the oogonial wall.* The manner of perforation was not made out in detail, but in seven of the eight specimens investi-

gated, it appeared that the oogonial wall was intact at the time that the sperm settled. In one specimen only was a distinct papilla present. Careful inspection indicated that the papilla was covered by a thin wall, and that it was not due to the protrusion of naked material from the oosphere. The general impression was gained that the wall between the two gametes was softened, possibly by the co-operation of both, and that the eversion of the rim of the pore was due to moulding caused by the emergence of the egg: the thin rim around the pore suggests some process of dissolution.

(3) *The fate of the cilium.* The cilium always disappeared suddenly when the bodies of the gametes were nearly or quite united. Although the fate of the cilium was not clearly determined, it seems that the cilium falls over on to the naked surface of the fusion body and then mingles with it, just as a streak of honey sinks into a drop of the same fluid. The egg never emerged with an obvious cilium attached to it, in the way figured by Lagerheim (17).

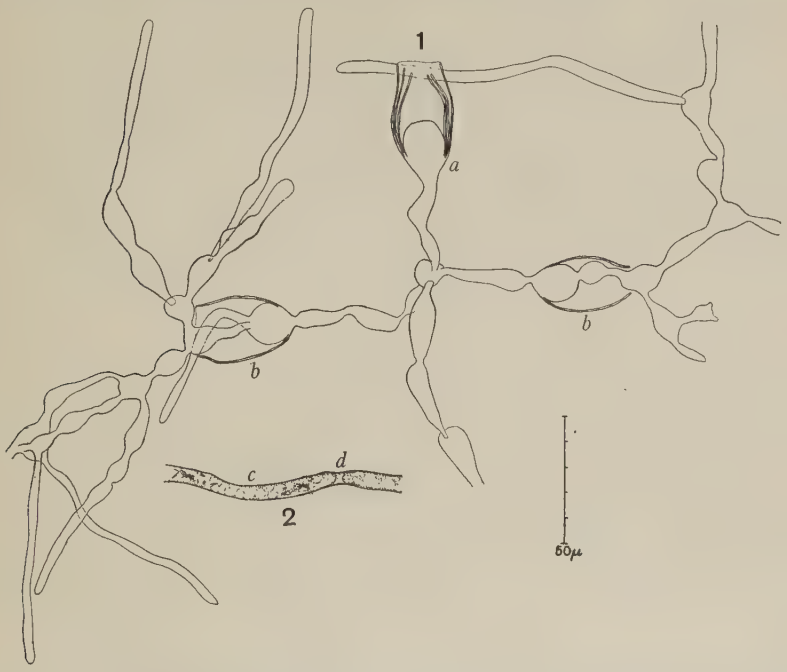
(4) *Migration.* In one only of the eight specimens watched was the egg seen to move outwards before the body of the sperm had sunk completely into it. In the one exceptional specimen it seems that the female gamete showed an unusual degree of motility. Woronin (44) seems to have thought that fertilisation might sometimes occur outside the oogonium but this idea appears to be a conjecture not supported by much evidence. The manifestation of power of movement by the female gamete is of considerable interest in connection with the work of Kniep (15, 16) on *Allomyces javanicus*, and it appears likely that there is a close systematic affinity between *Monoblepharis* and *Allomyces*. Although he does not draw special attention to the matter, Kniep shows in his figures that the hyphal contents of *Allomyces* are much vacuolated: vacuolisation is undoubtedly a characteristic feature of the hyphae of *Monoblepharis*. If it can be shown that the female gamete of *Monoblepharis* often manifests a greater degree of motility than has been generally conceded to it, we have another significant likeness between the genera. Reference may be made in passing to the great likeness shown in the figures, between the papillae drawn by Kniep in *Allomyces*, and those indicated many years ago by Sorokin (32) in his pictures of those mysterious genera *Tetrachytrium* and *Zygochytrium*, and also to certain resemblances in the descriptions of the pigmentation of *Allomyces* and *Zygochytrium*. We may have, in these four genera, a fairly closely related group lying at the base of the filamentous Phycomycetes.

### *Gonapodya* Fischer

The genus *Gonapodya* was erected by Fischer (8) for an organism named *Monoblepharis prolifera* by Cornu (6, 7), but not described by him, and later named *Saprolegnia siliquaeformis* by Reinsch (29). Thaxter (35) found this species in North America, and added a second species,

*Gonapodya polymorpha*. Although *Gonapodya* has been found several times in Europe and in North America, there seems to be no British record.

An indifferent specimen agreeing with the figure given by Thaxter(35) of *Gonapodya siliquaeformis* (Reinsch) Thaxt., was found on the twig collected at Forest Row in 1930. The material showed nothing worthy of special note, and drawings were not made of it.




Text-fig. 6. *Gonapodya polymorpha* Thaxter. 1. A portion of the mycelium, showing sporangial proliferation (*a*) and the production of new branch systems through old sporangia (*b*). 2. Portion of a hypha, showing vacuolisation (*c*), and a plug of cellulin (*d*); all the hyphae shown in 1 were occupied by contents of the kind drawn here.

In the early summer of 1931, the second twig from Forest Row was placed for a few hours in contact with freshly boiled twigs of *Fraxinus excelsior*, and the latter were then placed separately in vessels of water and inspected from time to time. They developed a fair growth of *Dictyuchus monosporus*, and little else. In October, 1931, however, a specimen was taken from one of these twigs, agreeing in its characters with *G. polymorpha* Thaxt. (Text-fig. 6). The affinity to *G. polymorpha* is shown by the elongated segments, in which cellulin plugs were more or less readily found. A special point of interest, and one apparently not previously noted in *G. polymorpha*, is the formation

of new branch systems by the growth of old hyphae through and beyond emptied sporangia: this phenomenon is not uncommon in *Saprolegnia*, which, like *Gonapodya*, renews its sporangia by proliferation. The younger hyphae showed distinctly vacuolated contents, but the vacuolisation was much less distinct and peculiar than in *Monoblepharis*. Laibach (18), on cytological evidence, has suggested a relationship between *Gonapodya* and *Monoblepharis*, but this idea, though a likely one, still awaits complete proof.

### *Blastocladia* Reinsch (29)

The genus *Blastocladia* has been recorded from the continent of Europe (24, 29), and from North America (36, 11, 12), but, apparently, not hitherto from Britain.

Two very indifferent specimens of a fungus undoubtedly belonging to this genus were scraped from the twig collected at Forest Row in 1930. The material was not good enough for specific determination, but, so far as could be judged, belonged to *Blastocladia Pringsheimii* Reinsch.

### Concluding remarks

The work which has been briefly described has been carried on in the intervals of other occupations: the results obtained indicate that a great deal more remains to be done, and could be done by workers having bodies of water within easy reach, and, preferably, away from a town. We still need much information about the biology of aquatic fungi. There is a general impression that these things are rare and difficult to find, but it has still to be shown that this impression is well founded. Of the fungi which have been referred to in the foregoing pages, not one is completely worked out, and most of them have been seen by only a few workers and on only a few occasions. They do not seem to be easy organisms to manipulate in the laboratory, but they certainly merit further study.

### Summary

1. During the past two and a half years a number of fungi, known to occur in Europe and in North America, have been found for the first time in this country. They include: *Thraustotheca clavata*, *Geolegnia* sp., *Zoophagus insidians*, *Lagenidium Syncytiorum* (?), *Tetracladium Marchalianum*, *Pythiomorpha gonapodioides*, *Monoblepharis sphaerica*, *M. polymorpha*, *Gonapodya siliquaeformis*, *G. polymorpha* and *Blastocladia Pringsheimii* (?).

2. The union of the gametes of *Monoblepharis polymorpha* is described.

3. The female gamete of *Monoblepharis* may sometimes begin to emerge from the oogonium before the gametes have completely fused.

## REFERENCES


(1) Claussen, P. "Zur Entwicklungsgeschichte der Ascomyceten. *Pyronema confluens.*" *Zeitschr. f. Bot.* IV (1912).

(2) Coker, W. C. *The Saprolegniaceae with notes on other Water Molds.* Univ. of N. Carolina Press, 1923.

(3) —— "Other water molds from the soil." *Journ. Elisha Mitchell Sci. Soc.* XLIII (1927), 207–26.

(4) Coker, W. C. and Braxton, H. H. "New water molds from the soil." *Journ. Elisha Mitchell Sci. Soc.* XLII (1926), 139–47.

(5) Collins, M. I. "Note on certain variations of the sporangia in a species of *Saprolegnia.*" *Proc. Linn. Soc. New South Wales*, XLV (1920), 277–84.

(6) Cornu, M. "Note sur deux genres nouveaux de Saprolegniées." *Bull. Soc. Bot. France*, XVIII (1871), 58–9.

(7) —— "Monographie des Saprolegniées. Étude physiologique et systématique." *Ann. Sci. nat. Bot.* (v), XV (1872), 5–198.

(8) Fischer, A. *Phycomycetes*, in Rabenhorst's *Krypt.-Flora*, I, IV (1892), 367–83.

(9) Harvey, J. V. "A study of the water molds and Pythiums occurring in the soils of Chapel Hill." *Journ. Elisha Mitchell Sci. Soc.* XLI (1925), 151–64.

(10) Kanouse, B. B. "Physiology and Morphology of *Pythiomorpha gonapodioides.*" *Bot. Gaz.* LXXIX (1925), 196–206.

(11) —— "On the distribution of the water molds, with notes on the occurrence in Michigan of members of the Leptomitaceae and Blastocladiaceae." *Mich. Acad. Sci. Arts Letters*, V (1925), 105–13.

(12) —— "A monographic study of special groups of the water molds. I. Blastocladiaceae. II. Leptomitaceae and Pythiomorphaceae." *Amer. Journ. Bot.* XIV (1927), 287–306, 335–57.

(13) Klebahn, H. "Studien über Zygoten. II. Die Befruchtung von Oedogonium Boscii." *Jahrb. f. wiss. Bot.* XXIV (1892), 235–67.

(14) Kniep, H. *Die Sexualität der niederen Pflanzen.* Fischer, Jena, 1928.

(15) —— "*Allomyces javanicus* n.sp., ein anisogamer Phycomycet mit Planogameten." *Ber. d. d. Bot. Ges.* XLVII (1929–30), 199–212.

(16) —— "Über den Generationswechsel von Allomyces." *Zeitschr. f. Bot.* XXII (1930), 433–41.

(17) de Lagerheim, G. "Mykologische Studien. II. Untersuchungen über die Monoblepharideen." *Bihang t. K. Svensk. Vet.-Akad. Handl.* XXV (iii) (1900), 3–42.

(18) Laibach, F. "Zur Zytologie von Monoblepharis." *Ber. d. d. Bot. Ges.* XLIV (1926), (59)–(64).

(19) —— "Zytologische Untersuchungen über die Monoblepharideen." *Jahrb. f. wiss. Bot.* LXVI (1927), 596–630.

(20) Lechmere, A. E. "An Investigation of a Species of *Saprolegnia.*" *New Phyt.* IX (1910), 305–19.

(21) —— "Further Investigation of methods of reproduction in the Saprolegniaceae." *New Phyt.* X (1911), 167–203.

(22) Massee, G. *British Fungi, Phycomycetes and Ustilagineae.* London, 1891, pp. i–xv, 1–232.

(23) von Minden, M. "Ueber Saprolegniineen." *Centralbl. f. Bakt.* (ii), VIII (1902), 805–10, 821–5.

(24) —— "Chytridineae, Ancylisteae, Monoblepharidineae, Saprolegniineae." *Kryptogamenflora Mark Brandenburg*, V (1912), 209–612.

(25) —— "Beiträge zur Biologie und Systematik einheimischer submerser Phycomyceten." *Mycol. Unters. u. Ber.* von Dr R. Falck, II (1916), 146–255.

(26) Petersen, H. E. "Studier over Ferskvands-Phykomyceter." *Bot. Tidsskr.* XXIX (1909), 345–440.

(27) —— "An account of Danish freshwater Phycomycetes, with biological and systematic remarks." *Ann. Mycol.* VIII (1910), 494–560.

(28) Ramsbottom, J. "A list of the British species of Phycomycetes, etc., with a key to the genera." *Trans. Brit. Myc. Soc.* v (1914–16), 304–17.
(29) Reinsch, P. F. "Beobachtungen über einige neue Saprolegnieae, über die Parasiten in Desmidien-Zellen, und über die Stachelkügeln in Achlya-Schlauchen." *Jahrb. f. wiss. Bot.* xi (1878), 283–312.
(30) Scherffel, A. "Über einige Phycomyceten." *Rept. Proc. Fifth Intern. Botan. Congress, Cambridge*, 1930 (1931), pp. 372–3.
(31) Sommerstorff, H. "Ein Tierefangender Pilz (*Zoophagus insidians* nov.gen., n.sp.)." *Österr. Bot. Zeitschr.* lxi (1911), 361–73.
(32) Sorokin, N. "Einige neue Wasserpilze." *Bot. Zeit.* xxxii (1874), 305–15.
(33) Sparrow, F. K. "A note on the occurrence of two Rotifer-capturing Phycomycetes." *Mycologia*, xxi (1929), 90–6.
(34) Thaxter, R. "New or peculiar aquatic fungi. 1. *Monoblepharis*." *Bot. Gaz.* xx (1895), 433–40.
(35) —— "New or peculiar aquatic fungi. 2. *Gonapodya* Fischer and *Myrioblepharis* nov.gen." *Bot. Gaz.* xx (1895), 477–85.
(36) —— "New or peculiar aquatic fungi. 3. *Blastocladia*." *Bot. Gaz.* xxi (1896), 45–52.
(37) —— "Mycological Notes, 2. Notes on *Monoblepharis*." *Rhodora*, v (1903), 103–8.
(38) von Tiesenhausen, M. "Beiträge zur Kenntnis der Wasserpilze der Schweiz." *Arch. Hydrobiol. und Planktonkunde*, vii (1912), 261–308.
(39) Valkanov, A. "Über Morphologie und Systematik der rotatorien-befallenden Pilze." *Arch. f. Protistenk.* lxxiv (1931), 5–17.
(40) Weston, W. H. "The development of *Thraustotheca*, a peculiar water-mould." *Ann. Bot.* xxxii (1918), 155–73.
(41) von Wettstein, F. "Das Vorkommen von Chitin und seine Verwertung als systematisch-phylogenetisches Merkmal im Pflanzenreich." *Sitzungsber. Akad. Wiss. Wien*, Math.-nat. Kl. (i), cxxx (1921), 3–20.
(42) de Wildeman, E. "Notes Mycologiques, Fasc. 2, 3, 4, 6." *Ann. Soc. belge Micr.* xvii (1893), 35–68; xviii (1894), 135–61; xix (1895), 59–82, 191–232.
(43) —— "A propos du genre *Tetracladium*." *C. R. Soc. Biol. Paris*, lxxxiii (1920), 192–4.
(44) Woronin, M. "Beitrag zur Kenntnis der Monoblepharideen." *Mém. de l'Acad. Imp. de St Pétersbourg*, Phys.-math. Cl. (viii), xvi (1904), 1–24.

# A STUDY OF SOME *PHOMA* SPECIES

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(With Plates I and II)

The genus *Phoma* is a member of the Fungi Imperfecti. It belongs to the Hyalosporae section of the family Phomaceae (Sphaerioidaceae), order Phomales (1). The diagnostic features of the genus *Phoma* are—"Pycnidia immersed, erumpent or with beak piercing the epidermis, lenticular to globose; thin membranous; opening by a pore, conidia small (less than 15 $\mu$), ovate to elongate, continuous, hyaline or green. Conidiophore short or almost obsolete" (2).

The perfect stages of a few species of *Phoma* have been established. Thus, for example, *Phoma Betae* and *P. sarmentella* are conidial forms of the Ascomycetes *Mycosphaerella tabifica* and *Diaporthe sarmentella* respectively.

Almost all the known species of *Phoma* and *Phyllosticta* have been described in connection with their pathological or symbiotic relationships—the source from which the material was obtained for study being the host with which the fungus was associated. Given a species of *Phoma*, the original source of which is unknown, it is interesting to trace its relationships. It is only when a problem of this nature presents itself that the need for an improved method of classification of the various species becomes evident.

Formerly, the genera *Phoma* and *Phyllosticta* were regarded as distinct, on the grounds that the former was caulicolous while the latter was foliicolous. This distinction is not, however, consistently maintained and is not sufficient for generic differentiation. Thus Cunningham (3) has shown that *Phoma Lingam* attacks the leaves of swedes and cabbages, and according to Stevens (2) *Phyllosticta solitaria* attacks twig, leaf and fruit of apple. Jamieson (4) shows that *Phoma destructiva* attacks stem, leaf and fruit of tomato. In Clements and Shear (1), the genera *Phoma* and *Phyllosticta* are retained as distinct on the grounds that the pycnidia produced by *Phyllosticta* occur on discoloured areas. This view appears to be untenable, since Jamieson has shown that *Phoma destructiva* produces pycnidia in dark areas on tomato leaves, a fact which we have confirmed, and further we have found that *P. destructiva* produces pycnidia in dark areas on ivy

leaves. Also, Cunningham has shown that *Phoma Lingam* produces abundant pycnidia in discoloured areas on the leaves of swedes.

Furthermore, it is possible that what are now regarded as distinct species of *Phoma* are really identical—in fact, in some cases the synonymy has been established. Thus Cunningham (3) has established the identity of the following species: *Phoma Lingam* (Tode) Desm., *P. siliquastrum* Desm., *P. oleraceae* Sacc., *P. Brassicae* Sacc., *P. napobrassicae* Rostr. and *Phyllosticta Brassicae* Curr. *Phoma Lingam* is the name he adopts.

Allescher (5) describes about 490 species of *Phyllosticta* and about 570 species of *Phoma*. Given that these two genera are identical, and calling the genus *Phoma*, there are in all over one thousand species described. The synonymy of some of these has been proved, but the number of species is still too great, and the characteristics of all too much alike to ensure the unquestionable identity of any given species. Thus, for example, according to Allescher (5) and Stevens (2), all species of *Phoma* have spores measuring less than 15 $\mu$ in length. Considering the fact that 590 species are described and that the spores mostly have the same shape, it is clear that the variation in spore measurement cannot be appreciable, and hence the spores of several species have the same dimensions. The same applies to the dimensions of the pycnidia, so that these structures are of little value in an attempt at identification. The classification hitherto adopted (5) is based on the host plants and on morphological characters. This method is not satisfactory and, unless some supplementary method is adopted, the identification of a species of *Phoma* occurring in such a habitat as milk, cream, butter or water is almost impossible.

Brooks and Searle (6), in a discussion on some fungi causing tomato diseases, state: "These showed great variability in characters which are generally looked upon as specific, such as size of spores, guttulation and shape of spores, and one was forced to the conclusion that a number of the so-called species in genera like *Phoma*, *Ascochyta* and *Diplodina* are nothing more than varieties of one and the same fungus."

The present work was first undertaken with a view to the identification of two species of *Phoma*, one of which occurred in milk, cream, butter and water, and the other in butter only. For reasons already stated, the identification was found extremely difficult. The species found in butter only agrees closely with the description and behaviour of *Phoma destructiva* Plowr. The identity of this species was established by experiment. It was found impossible to identify the species occurring in milk. Its behaviour was more like a saprophyte than a parasite. It was then thought that perhaps it was a soil form—one possessing symbiotic properties—but again the identification of such species is difficult, and the only forms of which details could be obtained were *P. radicis-Callunae* Rayner and *P. terrestris* and it did

not agree with either of these, either in growth form or in gelatine liquefaction; *P. radicis-Callunae* liquefies gelatine(7) rapidly, while the species in question shows only slight liquefaction in five weeks, and *P. terrestris* produces a characteristic red colour when grown on potato agar—a character not shared by the species isolated from milk.

This difficulty in identification led to the adoption of a different point of view, and it was decided to make a comparative study of the cultural and physiological properties of the two species of *Phoma* as well as those of *P. Lingam*, *P. Betae*, *P. radicis-Callunae*, *P. solanicola*, *P. terrestris* and *Phyllosticta hedericola*. The last was isolated from ivy leaves growing in the grounds at University College, Cork.

The physiological properties studied were: growth on different media; action on nutrient gelatine, on plain milk, on calcified milk, on litmus milk; the presence or absence of diastase; sugar fermentations, and growth in alcohols and dextrin. The effect of acid media on growth was also noted. In this way it was hoped, by analogy with the methods used for the classification of bacteria, to make possible a scheme of classification for the various species of *Phoma* based on cultural, morphological and physiological characteristics. This work is by no means complete, owing to the limited number of species studied, but its chief object is to make clear the difficulties and thus to be of some help to future workers on the subject.

## Experimental

The methods adopted for the identification of the species of *Phoma* isolated from milk, cream and butter were:

(1) A study of their mode of growth on culture media and comparison with published descriptions.

(2) Morphological characteristics; dimensions of spores and pycnidia.

(3) Inoculation experiments—carried out with a view to finding a host which the fungus attacked, and if it were found pathogenic to any particular plant, comparison was made with a known species pathogenic to the same plant, and in this way its identity established.

### *Method of isolation from milk and butter*

In the routine study of samples of milk, cream and butter in the dairy bacteriology department of the College, it is customary to estimate the number of yeasts and moulds present by plating with nutrient lactose agar which has had its *p*H adjusted to 3·5 and incubating at 21° C. for a week. From time to time, species of *Phoma* were found growing in the Petri dishes. These were examined microscopically; the species of *Phoma* found in milk was always the same. This species, which also occurred in cream and butter, as it could not be definitely identified, will be named *Phoma hibernica*. (It is

interesting to note that the same species was also isolated from samples of water received from creameries.) A species isolated from butter was identified as *P. destructiva*. It is possible that other species of *Phoma* occurred in the samples tested, but that, owing to the acidity of the medium, their growth was inhibited.

Phoma hibernica *isolated from milk, cream, butter and water*

The media used for studying this form were Czapek agar, prepared according to the formula given by Thom (8), nutrient lactose agar, nutrient glucose agar, potato agar and Barnes's medium (Gwynne Vaughan and Barnes (9)). It was found that the optimum temperature for growth and pycnidium formation was 18–21° C. The type of colony produced was the same on all media except Barnes's medium, on which only a few hyphae were formed. On all the other media, a flat compact circular colony was produced, of which all the hyphae were submersed, and which produced abundant imbedded pycnidia on the upper surface.

The rate of growth and relative production of pycnidia is greatest on potato agar—least on Barnes's agar. Growth is equally good on nutrient lactose, nutrient glucose and Czapek agar. Continued culture on the three last-named media leads to staling, to a reduction in the sporing capacity and to a change in the colour of the pycnidia from dark brown to pale pink. Plate I, fig. 1, shows a colony on potato agar—fig. 2 shows a colony on nutrient lactose agar, both three weeks old. It can be seen that growth and pycnidial production on potato agar is greater than on lactose agar; the pycnidial bearing regions form a number of concentric rings on the potato medium, whereas this arrangement is absent from the nutrient lactose agar colony. It can also be observed that the periphery of the colony is quite regular. The following table shows the rates of growth and the description of the colonies on potato agar and nutrient lactose agar for a period of ten days. The source of the culture was the same.

The pycnidia are imbedded structures and open by one, two or three ostioles, according to the size of the pycnidium. The pycnidium may be either globular, flask-shaped or lenticular. All the hyphae stain blue with cotton blue, but the cells composing the wall of the pycnidium are generally brown and do not stain very readily in cotton blue. Microtome sections of the pycnidia were prepared for the purpose of taking the dimensions of the pycnidia and spores. The pycnidia varied in size from $60 \times 50\,\mu$ to $108 \times 200\,\mu$. Such dimensions as $72 \times 65\,\mu$ and $80 \times 75\,\mu$ were frequent. The spores are hyaline, one-celled, oblong, bluntly rounded at both ends and frequently biguttulate; they measure $4 \times 5$–$7\,\mu$. A few are rounded, $3\,\mu$ in diameter. (As these dimensions agree with those of several species described in the literature, they are of little value in identification.)

Table I. *Phoma hibernica* (Temp. 18° C.)

| Time (days) | Medium: Nutrient lactose agar | Medium: Potato agar |
|---|---|---|
| 2 | Very slight growth | Small circular patch of hyphae |
| 4 | Colony $\frac{1}{4}$ in. in diam. Growth flat, no pycnidia evident | Colony $\frac{1}{2}$ in. in diam. Growth flat. Pycnidia abundant—brownish black. No shedding of spores |
| 6 | Colony nearly $\frac{1}{2}$ in. in diam. Light brown pycnidia on older parts of colony | Colony nearly 1 in. in diam. Pycnidia abundant except at extreme periphery. Colony brownish under pycnidium-bearing region |
| 8 | Size of colony 1 in. in diam. Pycnidia abundant. Spores shed from pycnidia as a flesh-coloured exudate | Size of colony 2 in. in diam. Growth very compact and regular. Inner region of colony $1\frac{3}{4}$ in. in diam., densely covered with pycnidia. Spores not shed |
| 10 | Colony slightly larger. No change of colour under colony | Spores shed as a flesh-coloured exudate |

### Inoculation experiments

For inoculation experiments, hanging-drop cultures in distilled water or portions of cultures on solid media were transferred to plants by means of a sterile needle; both wounded and unwounded surfaces were always treated. Untreated plants were kept as controls. The optimum conditions for infection were preserved by placing some plants in glass chambers and shading from direct light.

The other plants were sprayed with sterilised distilled water two or three times daily. The following plants were inoculated: cabbage, charlock, ragwort, tomato, *Sonchus* and lavender in leaf and stem, and daisy and lettuce in leaf only.

The plants were kept under close observation but no infection occurred—the plants remained quite healthy throughout.

Since the food of cattle consists to a large extent of root crops, it was thought that perhaps the fungus had come from that source. Consequently, some sound mangolds, turnips, carrots, beet-root and potatoes were sterilised by immersing in a 0·1 per cent. mercuric chloride solution and afterwards washed in several changes of sterilised distilled water. Portions of the mycelium were then transferred by means of a sterilised needle to both wounded and unwounded surfaces of the roots.

All the "roots" and tubers inoculated were placed in moist chambers at room temperature and kept in the dark. Careful records were kept, but, even after weeks, no infection had occurred. Where root or tuber had been wounded, a slight growth of superficial hyphae took place, but sections showed no evidence of penetration and the mycelium was short-lived.

Some species of *Phoma* attack tomato and one species attacks apples. These fruits were inoculated, the method of treatment being similar to that employed with turnips. Green and ripe fruits were used and controls were kept. All the fruits were placed in sterilised desiccators containing sterilised distilled water in the lower chamber. No growth took place on the apples. On the wounded tomatoes a very slight superficial growth of mycelium developed, but even after weeks there was no apparent injury to the fruits and sections showed that penetration had not taken place.

These experiments, therefore, demonstrated that the species of *Phoma* was not one of the following: *Phoma Lingam*, *P. Betae*, *P. Lavendulae*, *P. Lactucae*, *P. destructiva* or other forms pathogenic to tomatoes, *P. Mali*, *P. Pomi*, *P. tuberosa*, *P. terrestris*, *Phyllosticta jacobea*, or *P. Sonchi*.

Stabs of the fungus were made on nutrient gelatine and the tubes kept at room temperature for a month. Growth and pycnidium formation were good, but the amount of liquefaction was less than 5 per cent. Hence the species is not *Phoma radicis-Callunae*.

### Phoma destructiva *isolated from butter*

The media used for cultural studies of this species were Czapek agar, nutrient lactose agar (*p*H 7·0), potato agar, and Barnes's medium. Potato agar was found to be the best medium for growth. Pl. II, fig. 3, shows a 21-days old colony on potato agar. Note the dark centre and the few pycnidia. The following table gives the rate of growth and description of the fungus on potato agar, nutrient lactose agar and Barnes's medium.

*Description of fungus*. The mycelium growing on nutrient lactose agar is composed of robust septate branching hyphae. The cells of the aerial hyphae are long, being four or five times their width, but the length and diameter of the cells of the submersed hyphae vary considerably. Comparatively few hyphae consist of long narrow cells. By far the greater portion of the mycelium is composed of short irregular cells, sometimes almost completely rounded off from each other. This was a feature common to all the species of *Phoma* studied, and was of little value for purposes of identification.

The mycelium forms a very compact mat at the surface of the substratum in which the pycnidia are imbedded—and the irregularity of the cells becomes more marked in this region. The mycelium stains blue in cotton blue, and under the microscope bright refractive bodies are observed in some cells. These are oil drops for they dissolve in ether and stain brown in a 1 per cent. aqueous solution of osmic acid (9). Fat is present in great quantity but is not uniformly distributed, and is absent from some cells.

Few pycnidia are formed. They are imbedded and are generally covered over by the aerial mycelium. They are either globular or

flask-shaped and open by an ostiole on the surface of the substratum. They are brown or black in colour. Microtome sections were prepared and the dimensions of the pycnidia and spores taken. The pycnidia vary from 60 × 100 μ to 150 × 220 μ. The spores are oblong, rounded at the ends and some are biguttulate. Their average size is 3·5 × 6–7 μ (variation in size 3 × 4 μ to 4 × 8 μ). The spores are shed as a slimy exudate. Pl. I, figs. 1, 3, 4, show colonies of *Phoma hibernica*, *P. destructiva* and *P. Lingam*, respectively—all three weeks old, grown upon potato agar at 21° C.

Table II. *Phoma destructiva* (Temp. 18° C.)

| Time (days) | Medium | | |
|---|---|---|---|
| | Potato | Lactose | Barnes's |
| 2 | Growth sparse—mycelium fluffy white | Poor growth. Mycelium white. Only a few aerial hyphae | No evident growth |
| 4 | Diam. of colony 1 in. Compact and fluffy towards centre. Sparse and lobed towards periphery—no pycnidia | Growth scant. Size of colony ½ in. Flat irregular growth—no pycnidia | A few radiating hyphae produced—not evident till culture is viewed against the light |
| 6 | Colony about 1½ in. in diam. No pycnidia | Colony ¾ in. in diam. Growth sparse towards periphery—no pycnidia | Colony a little larger |
| 9 | No pycnidia | No pycnidia | No pycnidia |
| 10 | Mycelium very fluffy—no pycnidia | Colony darkish towards the centre underneath | No pycnidia |
| 14 | Periphery lobed—colony compact and fluffy throughout. Colour brownish black underneath—sometimes olivaceous: grey on upper surface. A few pycnidia produced in the dark region | Size of colony about 3 in. in diam.—lobed at periphery. Aerial hyphae comparatively scarce. Colour of colony brown at periphery — brownish black in centre. A few pycnidia in the older parts of the colony. Mycelium grey on upper surface | No change in type of growth—no pycnidia |

### Inoculation experiments

The technique of the inoculation experiments was the same as that employed with the species of *Phoma* already described. The plants inoculated were: cabbage (leaf and stem), lettuce (leaf), lavender (leaf and stem), tomato (leaf, stem and fruit), potato (tubers).

The optimum conditions for infection were preserved, viz. a suitable temperature (greenhouse) and a moist atmosphere. The tomato plants were placed in glass chambers and shaded from direct light. Controls were kept by placing untreated plants under similar conditions. For the purposes of comparison and control a number of

Table III. *Phoma Lingam*

| Time (days) | Host: Cabbage | Tomato plants | Tomato fruits | Potato |
|---|---|---|---|---|
| 3 | Small dark lesion produced | No change round wounded surface | A few aerial hyphae produced on wound | No change |
| 5 | Lesion much larger | Very small discoloured area round infected wound | No further change | No change |
| 10 | Large area of stem affected —lesion brown in the centre black towards periphery | No further development | Mycelium seemed to be dying off | A small patch of fluffy hyphae produced |
| 21 | Leaves of plant begin to wilt | No change | No injurious effect | No injurious effect |

Table IV. *Phoma destructiva*

| Time (days) | Host: Cabbage | Tomato plants | Tomato fruits | Potato |
|---|---|---|---|---|
| 3 | No change | A dark lesion produced round the point of inoculation on the wounded surfaces of stem and leaf. No infection of unwounded surface | Patch of fluffy hyphae produced on wounded surface | No change |
| 5 | No change | Lesion 1 sq. cm. in area | Growth very profuse on wounded surface; sections show penetration has taken place. Hyphae very abundant in the cells of infected region | Slight discoloration of wounded surface |
| 10 | No change | The whole leaf wilted—large lesion on stem | Depression and discoloration of regions round wound—lesion about 1 in. in diameter | No further development |
| 21 | No change | | Fruit completely destroyed, tissues quite soft. Pycnidia produced. Mycelium carbonaceous at surface | |

No change occurred in Lettuce, Lavender and controls.

similar plants were inoculated with *Phoma Lingam*. Several inoculations were made and all gave similar results. In tabulating the records, therefore, one example is taken in each case. Table III gives the records of the inoculations with *Phoma Lingam*, Table IV those of the species isolated from butter (*Phoma destructiva*).

From the above tables it is evident that the *Phoma* obtained from butter is pathogenic to tomatoes and slightly pathogenic to potatoes, but has no effect on cabbage, lettuce or lavender. *Phoma Lingam* attacks cabbage but not lettuce, lavender or potato. It is weakly parasitic on tomato.

Pl. I, fig. 5, shows a tomato on which the species from butter has been growing for twenty-eight days. The experiments were repeated several times with tomato fruits, and the species which occurred in butter only always caused infection. To ensure the identity of the fungus with that used for inoculation, cultures of the mycelium from the tomato plants and fruits were taken and the colonies produced were all similar to the original.

It was concluded therefore that the fungus was *Phoma destructiva*, as it agreed very closely with all the available descriptions of this fungus.

Comparative study of *Phoma hibernica*, *P. destructiva*, *Phyllosticta hedericola*, *Phoma Lingam*, *P. terrestris*, *P. solanicola*, *P. radicis-Callunae* and *P. Betae*.

*Mode of growth on culture media at 21° C.*

The media used for the comparative study of the cultural characteristics of the above-named species were potato agar, nutrient lactose agar, Czapek agar, and Barnes's medium. It was found that all the species under observation grew well on potato agar. The colonies produced on nutrient lactose agar and Czapek agar were similar, while growth on Barnes's medium was always very sparse—the hyphae produced being visible only when viewed against the light. All the species are slow growing—under optimum conditions the diameter of a colony produced in a week rarely exceeds one and a half inches.

Tables V and VI summarise the cultural characteristics of the different species.

Of these species, *Phoma destructiva* and *Phyllosticta hedericola* are indistinguishable in culture. This led to a suggestion of their probable identity and a series of inoculations were carried out to test this. Some sterilised ivy leaves were inoculated with *Phoma destructiva* and others with *Phyllosticta hedericola* and kept in moist chambers. After four or five days dark lesions were evident around the point of inoculation and both fungi produced identical effects on the leaves (see Pl. I, fig. 6). Pycnidia were borne at the surface in both, and spores were extruded as a pink tendril from each pycnidium.

## Table V. *Potato agar*

*Phoma hibernica*

Colony circular, margin regular compact; hyphae submersed; colony brownish underneath older parts, pycnidia abundant uniformly distributed—brownish black to pale pink. Spore mass flesh-coloured

*Phoma destructiva*

Growth rather fluffy. Margin of colony lobed. Aerial hyphae grey. Colony carbonaceous under aerial hyphae—olivaceous underneath. Pycnidia few or absent, rarely visible when viewed from above

*Phoma Lingam*

Growth very compact. Margin of colony irregular. Black underneath. Aerial hyphae white turning grey with age. Surface carbonaceous pycnidia few, scattered

*Phoma terrestris*

Colony very compact, fluffy. Aerial hyphae greyish white. Underneath the colony shows concentric colour rings—white at the margin, black inside and red in the centre. Pycnidia abundant but not uniformly distributed (crimson patches developed in Petri dish cultures after three months)

*Phoma solanicola*

This forms a sparse striated, fluffy colony, which is dull grey on the upper surface and greenish black underneath. Pycnidia absent

*Phoma radicis-Callunae*

The colony consists of submersed hyphae with a few white aerial hyphae. Colour light brown—translucent

*Phoma Betae*

Colony compact, black on both surfaces. Aerial hyphae few and either dull brown or black

*Phyllosticta hedericola*

Like *Phoma destructiva* in every respect

## Table VI. *Nutrient Lactose Agar*

*Phoma hibernica*

Colony circular, margin regular compact; hyphae submersed. Pycnidia abundant uniformly distributed, brownish to pale pink

*Phoma destructiva*

Growth scant. Colony slightly fluffy irregular. Colour of colony brownish black in centre, underneath carbonaceous

*Phoma Lingam*

Growth sluggish, colony compact, downy aerial hyphae white. Pycnidia few or absent

*Phoma terrestris*

Growth similar to that on potato agar—showing same colour rings but the red more brilliant

*Phoma solanicola*

Colony flat, growth sparse striated underneath. Pycnidia absent

*Phoma radicis-Callunae*

Growth sluggish. Colony flat, light brown translucent

*Phoma Betae*

Growth sparse, colony flat, carbonaceous, no aerial hyphae

*Phyllosticta hedericola*

Like *Phoma destructiva*

Tomato fruits were also sterilised and inoculated and both fungi produced the same results, viz. a dark lesion round the point of inoculation and subsequent decay of the entire fruits. A detailed study of the morphological and physiological characteristics of the two forms confirmed their identity, so that one concludes that *Phoma destructiva* and *Phyllosticta hedericola* are identical.

To return to the comparison of the cultural characteristics—in all the species except *Phoma hibernica* and *P. radicis-Callunae*, the colony is very markedly carbonaceous underneath the aerial hyphae. *P. hibernica* can be distinguished readily from the other species by the almost complete absence of aerial hyphae and the abundance of pycnidia. *P. terrestris* is readily recognised by the deep red colour it produces in the substratum. Of the remaining species, *P. Lingam* can be distinguished in the young stages of growth by the downy white aerial mycelium. Microscopically the cells of the mycelium of all the species show a marked similarity. The submersed hyphae are very variable consisting partly of elongated regular cells, partly, and sometimes entirely, of short irregular cells. All the species examined contain an abundance of oil-drops when grown on potato agar.

The behaviour of the above-named species of *Phoma* when grown on neutral and acid media, on nutrient gelatine, on plain milk, on calcified milk, on litmus milk, on a nutrient medium containing starch and sugars, alcohols and dextrin, was studied to find out whether the cultural characters exhibited were accompanied by marked physiological activities and if so to put forward this aspect as a supplementary method of classifying the species of *Phoma*.

## Experimental

*Growth on neutral and acid media.*

To study the effect of change of *p*H on the growth of the species of *Phoma*, nutrient lactose agar was used, the hydrogen-ion concentrations of which were adjusted to 7·0 and 3·5. Each species was plated on the media in separate Petri dishes.

*Nutrient gelatine* (stab culture). The liquefaction of gelatine is an indication of the presence of proteolytic enzymes, and the rate of liquefaction due to a given organism is a measure of its proteolytic activity.

*Plain milk.* The experiments for the study of the action in plain milk were carried out in test-tubes ($6 \times \frac{5}{8}$ in.), each containing 10 c.c. of plain milk.

*Calcified milk.* The calcified milk tubes were prepared by placing 20 c.c. of milk in each of a number of test-tubes ($6 \times 1$ in.) containing 0·5 gm. of calcium carbonate. Clotting, with or without subsequent

digestion, is an indication of the presence of proteolytic enzymes and may be caused by pepsin, rennin or trypsin. Trypsin differs from the other two in causing digestion of the clot.

*Litmus milk.* The litmus milk tubes were prepared by placing 10 c.c. of litmus milk in test-tubes ($6 \times \frac{5}{8}$ in.). The action of litmus milk provides a test for acid or alkaline reaction with or without coagulation of curd and with or without subsequent digestion of curd.

*Starch*: presence or absence of diastase. This was studied by growing cultures on nutrient lactose agar and potato agar containing 1 per cent. soluble starch, and also on a mineral salt glucose agar containing 1 per cent. soluble starch, and after incubation for three days, flooding the Petri dishes with Lugol's iodine solution. A colourless zone round the colony was taken as an indication of the presence of diastase.

*Fermentation.* Fermentation was studied by inoculating Dunham's solution to which 1 per cent. of glucose, lactose, glycerine, mannitol and dextrin had been added. Smaller tubes filled with the solution were inverted in the larger tubes. There was no production of gas and no appreciable change of *p*H. In summarising the results of experiments, therefore, fermentations are omitted.

From the foregoing it is clear that while most of the species possess similar physiological properties, yet some properties present interesting differences which make them useful as a basis of classification. All are alike, or show inappreciable differentiation in their action on plain milk, calcified milk and litmus milk, and in their inability to ferment glucose, lactose, mannitol, glycerine or dextrin. Of the physiological characters, the action on gelatine is perhaps the most valuable in classification as here we find the most appreciable differences.

The following scheme for the classification of the species of *Phoma*, based on cultural and physiological properties, may be put forward tentatively:

A. Less than 5 per cent. liquefaction in three weeks.

Flat growth on potato agar and on nutrient lactose agar. Abundant production of pycnidia. Growth equally good on neutral and acid potato agar (*p*H 3·5) .....*P. hibernica.*

B. Little or no liquefaction in six days; marked liquefaction in three weeks.

(*a*) Fluffy growth on potato agar; aerial hyphae white or grey; pycnidia few. Parasitic on tomato plants and fruit and on ivy .....*P. destructiva.*

(*b*) Fluffy growth on potato agar, aerial hyphae black or brown; pycnidia absent. Parasitic on beet .....*P. Betae.*

Table VII.

| Species | Nutrient lactose agar | | Gelatine | Plain milk |
|---|---|---|---|---|
| | *p*H 7·0 | *p*H 3·5 | | |
| *Phoma hibernica* (N.S.) | Good growth and sporulation (Pl. II, fig. 1) | Good growth and sporulation (Pl. II, fig. 2) | Very slight liquefaction—less than 5 % in 3 weeks | Matted surface growth. No apparent action |
| *Phoma destructiva* | Good growth (Pl. II, fig. 3) | Growth very poor (Pl. II, fig. 4) | Less than 5 % in 6 days; 20 % in 3 weeks | Soft coagulation in 1 week followed by digestion |
| *Phyllosticta hedericola* | Good growth | Growth very poor | Less than 5 % in 6 days; 20 % in 3 weeks | Soft coagulation followed by digestion |
| *Phoma Lingam* | Growth and sporulation (Pl. II, fig. 7) | No growth | 25 % liquefaction in 6 days; 50 % in 3 weeks | Slight soft digestion in 1 week |
| *Phoma terrestris* | Good growth | Growth slow; colony compact fluffy | Less than 5 % in 6 days; 20 % in 3 weeks | Soft coagulation followed by digestion |
| *Phoma solanicola* | Good fluffy growth | Flat sparse growth | Marked liquefaction in 6 days; 20 % in 3 weeks | Soft coagulation followed by digestion |
| *Phoma radicis-Callunae* | Good growth | Little or no growth | Marked liquefaction in 6 days; 25 % in 3 weeks | Soft coagulation followed by digestion |
| *Phoma Betae* | Good growth (Pl. II, fig. 5) | Poor growth (Pl. II, fig. 6) | Less than 5 % liquefaction in 6 days; 15 % in 3 weeks | Soft coagulation followed by digestion |

| Species | Calcified milk | Litmus milk | Diastase | Diastatic action in mineral salt glucose agar |
|---|---|---|---|---|
| *Phoma hibernica* (N.S.) | Good growth, no apparent action | Slight alkaline reaction in 6 days | Absent | Absent |
| *Phoma destructiva* | Soft coagulation followed by digestion | Rennet-like digestion in 6 days | Absent or very slight production | Slightly positive |
| *Phyllosticta hedericola* | Soft coagulation followed by digestion | Rennet-like digestion in 6 days | Absent | Slightly positive |
| *Phoma Lingam* | Soft digestion in 10 days | Rennet-like digestion in 6 days | Absent | Slightly positive |
| *Phoma terrestris* | Soft coagulation followed by digestion | Rennet-like digestion in 6 days | | |
| *Phoma solanicola* | Soft coagulation followed by digestion | Rennet-like digestion | | |
| *Phoma radicis-Callunae* | Soft coagulation followed by digestion | Rennet-like digestion | | |
| *Phoma Betae* | Soft digestion in 1 week | Rennet-like digestion | Absent | Absent |

(*c*) Fluffy growth on potato agar; aerial hyphae white or grey. Colony red in older parts underneath .....*P. terrestris.*

C. Marked liquefaction in six days.

(*a*) Flat growth on potato agar; colony golden brown; pycnidia absent. Grows as a symbiont in the roots of *Calluna* .....*P. radicis-Callunae.*

(*b*) Fluffy striated olivaceous growth on potato agar. Parasitic on potato stems .....*P. solanicola.*

(*c*) Fluffy growth on potato agar: aerial hyphae downy white in young stages of growth. Pycnidia produced. Parasitic on *Brassica* spp. .....*P. Lingam.*

This method of classification, based on cultural and physiological properties, if applied, would possibly lead to a recognition of the identity of several forms at present described as separate species. It is clearly recognised that any scheme of classification of the species of *Phoma* will break down in the event of the discovery of their higher connections, but even a temporary classification is most desirable and may lead all the sooner to the discovery of the perfect stages.

## Summary

1. The classification of the species of *Phoma* is discussed.

2. A species of *Phoma* isolated from milk, cream, butter and water and a species isolated from butter only, are described.

3. The methods used for the identification of the two species are given in detail and the species isolated from butter is identified as *Phoma destructiva.*

4. A comparative study of the cultural characteristics and of the physiological properties of a number of species is given and a scheme of classification based on these characters put forward.

5. The species isolated from milk, cream, butter and water is described, but since it occurs frequently and so far does not agree with available descriptions of any known species, it is named *Phoma hibernica.*

Acknowledgement is made of the kindness of Dr St John Brooks, Lister Institute of Preventive Medicine, London, Dr Joh. Westerdijk, Centraalbureau Schimmelcultures, Baarn, Holland, Dr Paul Murphy, Albert College, Dublin, and Dr M. C. Rayner, London, in supplying cultures of various species of *Phoma* for comparison.

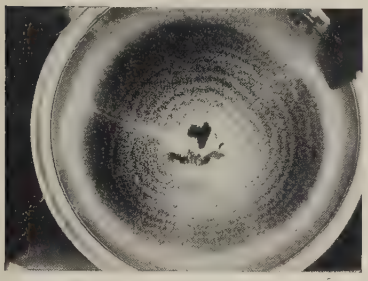

Fig. 1

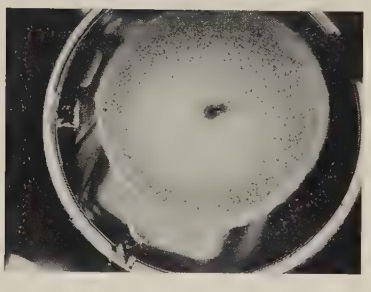

Fig. 2

Fig. 3

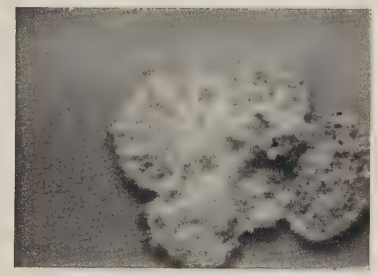

Fig. 4

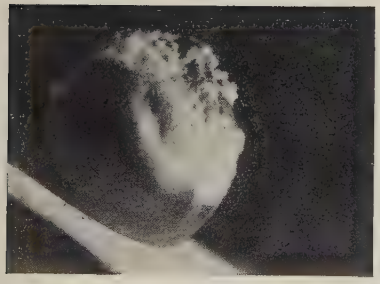

Fig. 5

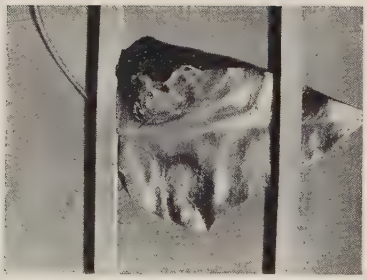

Fig. 6

## EXPLANATION OF PLATES I AND II

### Plate I

Fig. 1. Colony of *Phoma hibernica* on potato agar (3 weeks old).
Fig. 2. Colony of *P. hibernica* on nutrient lactose agar (3 weeks old).
Fig. 3. Colony of *P. destructiva* on potato agar (3 weeks old).
Fig. 4. Colony of *P. Lingam* on potato agar.
Fig. 5. Tomato showing attack of *P. destructiva.*
Fig. 6. Ivy leaf showing attack of *P. destructiva.*

### Plate II

(10 days old colonies)

Fig. 1. *Phoma hibernica* on medium *p*H 7·0.
Fig. 2. *P. hibernica* on medium *p*H 3·5.
Fig. 3. *P. destructiva* on medium *p*H 7·0.
Fig. 4. *P. destructiva* on medium *p*H 3·5.
Fig. 5. *P. Betae* on medium *p*H 7·0.
Fig. 6. *P. Betae* on medium *p*H 3·5.
Fig. 7. *P. Lingam* on medium *p*H 7·0.

## REFERENCES

(1) Clements, F. E. and Shear, C. L. *The Genera of Fungi*, 1931, New York.
(2) Stevens, F. L. *The Fungi which cause Plant Diseases*, 1921, New York.
(3) Cunningham, G. H. "Dry-Rot of Swedes and Turnips." *New Zealand Dep. Agr. Bull.* 133 (1927).
(4) Jamieson, C. O. "*Phoma destructiva* the cause of Fruit Rot of Tomato." *Journ. Agr. Res.* iv (1915), p. 1.
(5) Allescher, A. in Rabenhorst, L. *Kryptogamen-Flora*, 1, 6, Fungi Imperfecti (*a*), 1901.
(6) Brooks, F. T. and Searle, G. O. "An Investigation of some Tomato Diseases." *Trans. Brit. Myc. Soc.* vii (1921), p. 173.
(7) Rayner, M. C. and Smith, M. Llewellyn. "*Phoma radicis-Callunae.*" *New Phytologist*, xxviii (1929), 262.
(8) Thom, C. and Church, M. B. *The Aspergilli.* 1926.
(9) Gwynne Vaughan, H. C. I. and Barnes, B. *The Fungi.* 1927.
(10) Strasburger, E. and Hillhouse, W. *Practical Botany* (1911), p. 242.

# CONTRIBUTION TO OUR KNOWLEDGE OF THE ECOLOGY OF SEWAGE FUNGUS*

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(With Plate III)

## Introduction

The chief object of this short paper is to add further details and figures to the notes recently published (Butcher(5) and Butcher, Pentelow and Woodley(6)) on the growth and distribution of the community of polysaprobic organisms known commonly as Sewage Fungus.

The association† of polysaprobic organisms occurs in waters rich in decaying organic matter (Kolkwitz and Marsson(19)) and can be divided into a series of communities:

(1) The polysaprobic fauna (macroscopic).
(2) The polysaprobic Protozoa (microscopic).
(3) The polysaprobic bacteria, *i.e.* true bacteria.
(4) The polysaprobic Schizomycetes and true fungi.

Only this last group is dealt with. The characteristics of this community are that the organisms appear as fluffy fungoid growths or white films and are associated with waters rich in organic matter, a frequent source of which is domestic sewage. The following are the organisms considered in this community: *Sphaerotilus natans* Kütz., *Cladothrix dichotoma* Cohn, *Zoogloea ramigera* Itzig., *Beggiatoa alba* (Vauch.), *Leptomitus lacteus* Agardh, *Fusarium aquaeductum* (Radl. & Rab.) Sacc., *Penicillium fluitans* Tiegs, *Carchesium Lachmanni* (Clap. & Lach.), *C. spectabile* Ehrh.

It is necessary to find some convenient term for this community and "sewage fungus"‡ appears to be as satisfactory as any. Regarded from the purely scientific point of view the name may perhaps be a misnomer, for the community includes four species of Schizomycetes, one Phycomycete and two stalked Protozoa. Yet as a descriptive term of the characteristic growth, "fungus" can hardly be improved upon; "organisms" makes the community too comprehensive and includes the whole polysaprobic association. Similarly the adjective "sewage" does not cover the whole range of habitats in which

* Part of thesis approved of for the degree of Doctor of Philosophy in the University of London.

† This term is used in a general and not an ecological sense.

‡ Or "sewage fungus complex."

these organisms appear, yet "sewage" immediately suggests organic matter in a state of decomposition, and this seems to be the determining factor for the appearance of the community. "Sewage fungus" has also long been used extensively in all sewage engineering works, and as there seems no better understood term it is adopted throughout this paper, and can be defined as the "community of polysaprobic organisms with a fungus-like growth."

## General description of organisms

### *The* Sphaerotilus natans *group*

In this group are included a number of growth forms all of which possess rod-shaped bodies about 4–6 × 1–2 $\mu$, usually arranged in filaments but occasionally forming zoogloea. In the filament the individual cells are placed end to end within a mucilaginous tube. They are Schizomycetes and include *Sphaerotilus natans* Kützing, *Cladothrix dichotoma* Cohn, and some of the organisms described as *Zoogloea ramigera* Itzig. Various morphological forms obtained in artificial media have been described by Busgen (4), Ellis (10) and Linde (22), but similar forms which occur under natural conditions have been only incompletely described by Zopf (33) and Kolkwitz (18). As these various morphological forms seem to indicate certain physiological conditions under which the organisms are developed, it seems worth while to describe and name them.

(*a*) *Sphaerotilus natans* Kützing (21), according to its author, has the following characteristics:

(1) Filaments unbranched, arranged in more or less parallel series and, although there are separate sheaths to the filaments, they are massed together also by a common mucilage.

(2) Colonies very obvious, plumose or white, grey or yellowish.

(3) Individual cells (4–6 × 1–1·5 $\mu$) well defined and distinct, with homogeneous or granular contents.

This form is comparatively rare, usually occurring where growth is very rapid. It is referred to in the following pages as var. *typica*. When growing on agar the filaments are arranged in parallel series as in many other forms of this group.

Other well-marked varieties are:

(*b*) var. *vulgaris* nov.var. This differs from the type chiefly in the filaments not being embedded in a common mucilage in parallel series but being freely divergent. Its main characters are:

(1) Filaments unbranched, freely diverging, each with a free mucilaginous sheath but not embedded in a common mucilage.

(2) Colonies very obvious, plumose or tassel-like, white, grey or yellowish.

(3) Individual cells (3–6 × 1–1·5 $\mu$) distinct, with homogeneous or granular contents (see Figs. 1 and 2).

This form is extremely common, is often the dominant member of the community and is very rarely altogether absent. It forms large tassel-like growths from 1 to 10 cm. long attached to any object under the water, and it attains its best development in freely running water.

(*c*) var. *prolifera* nov.var. This resembles Zopf's form of *Crenothrix polyspora* figured in Ellis (11) and is characterised by:

(1) The larger filaments arranged in parallel series in a common mucilaginous mass with tufts of small filaments branching out from the main central mass.

(2) Colonies obvious, whitish, mucilaginous or gelatinous (*i.e.* of finer texture).

(3) Individual cells of the main filament 4–6 × 1–1·5 $\mu$, of the small tufts 3–4 × 1–1·2 $\mu$, distinct, particularly in the main filaments, contents homogeneous or granular (see Fig. 4).

This form is rare, but is found along with the two previous varieties forming tufts similar in size and form where growth is prolific.

(*d*) var. *Cladothrix* nov.comb. *Cladothrix dichotoma* Cohn (8), *Sphaerotilus dichotomus* Migula (24). According to Cohn the characters of his *Cladothrix dichotoma* are:

(1) Filaments with false dichotomous branching (likened by Cohn to a *Scytonema*). The branches may arise according to Linde (22) by the fusion of the mucilage sheath of two parallel threads, by a single cell (possibly a zoospore) attaching itself to the mucilage wall of another filament and growing there, and by the extrusion of one of the cells from the main filament which then grows into a separate filament. I have observed all these three types under natural conditions.

(2) No well-defined tufts are formed, but it usually appears as a dirty white film, with "frayed" edges formed by divergent or parallel filaments, attached to water plants and stones (see Kolkwitz (18)).

(3) Individual cells as a rule smaller than the above varieties (3–5 × 0·5–1 $\mu$), usually distinct but not always easy to resolve, usually with granular contents. There are a large number of figures of this variety in Zopf (33), Busgen (4), Ellis (11) and Linde (22) (see Fig. 3).

It still seems doubtful whether *Cladothrix dichotoma* Cohn and *Sphaerotilus natans* Kütz. are the same species. Zopf (33) on morphological grounds and Ellis (10) and Linde (22) from a study of the organism in culture consider them to be identical, and Migula (24) includes the two forms as species of the same genus. Zikes (32), however, from the results of culture work, considers the two distinct on account of the branching, the position of the flagellae, the liquefaction of gelatine and the assimilation of organic food-stuffs. Yet how unsatisfactory these distinctions are may be seen from the following considerations: (1) Branched filaments occur spasmodically in *Sphaerotilus natans* especially in the var. *vulgaris*. (2) A pure culture of one of these forms recently isolated, liquefies gelatine very rapidly (a *Sphaerotilus* cha-

racter) yet the organism shows branching and growth forms exactly like those figured by Linde(22) for *Cladothrix*. (3) The cells of *Sphaerotilus*, though usually larger than *Cladothrix*, may be found of varying size, and this seems to be correlated with the nutritional circumstances. (4) Zikes's results differ from those of Trommsdorff(29) particularly in the effect on the growth of the organism when sugar is added to a nitrate or ammonium sulphate medium and in the growth of *Sphaerotilus* in peptone water: Zikes records very little growth, Trommsdorff abundant growth.

It seems difficult to come to any conclusion about the occurrence of these two forms under natural conditions, since neither the morphological difference of branching nor the size of the cells is wholly reliable. Of the two rivers where the growths have been studied most intensively, viz. the Lark and Tees, *Cladothrix* was not observed in the former in early growths on the slides (one or two days) but occurred as occasional filaments among the var. *vulgaris*. The growth here was always prolific, and, as mentioned above, *Cladothrix* is usually found where the conditions of growth are not very favourable. *Cladothrix* is undoubtedly the prevailing form in the Tees, but in its sewage-polluted tributary (the Skerne), as well as sometimes in the main river itself near the confluence, *Sphaerotilus* also is present, judging from morphological characters. The general conclusion seems warranted that *Cladothrix* is a distinct ecological form characterised by being usually branched and with smaller cells, but there are no well-defined characters to separate it from the other forms outlined in this paper.

(*e*) var. *depauperatus* nov.var.

(1) Filaments unbranched, freely diverging, each with a free mucilaginous sheath and not embedded in a mucilaginous mass.

(2) Growth rarely obvious, the general appearance being similar to that of var. *Cladothrix* though minute tufts are sometimes formed.

(3) Individual cells distinguishable with difficulty. The contents are usually granular and appear similar to those of *Beggiatoa alba* filaments (see Fig. 5).

Both the general appearance and the conditions under which this variety exists suggest that it is a form induced by poor nutrition. It is usually found at the end of a stretch of river full of *Sphaerotilus natans* vars. *typica* and *vulgaris*, when these forms are diminishing, at the outfall of a comparatively purified sewage effluent, or after the end of a "campaign"* at a sugar-beet factory, when purification of the effluents has been brought about and the fungus is dying out.

(*f*) var. *transiens* nov.var. This appears to be a transitional form between *Sphaerotilus natans* Kütz. and *Zoogloea ramigera* Itzig. and is figured in Zopf(33). It is characterised by:

* Campaign is the term given to the period (usually September to February) when the sugar factory is working on the season's crop.

(1) Filaments in tufts or tangled in a spherical mass (0·01–1 mm. in diameter) in the centre or base of which the cells are arranged in an irregular, formless manner and not as free tangled filaments. Sheaths of individual filaments distinct.

(2) Colonies definite, of various shape from minute spherical masses (0·01–1 mm.) to large tassel-like gelatinous tufts up to 3 cm.

(3) Individual cells (2–4 × 0·5–1 $\mu$) distinct with homogeneous contents (see Fig. 6).

This variety is not uncommon among dense growths of *Sphaerotilus natans* var. *vulgaris* and *Zoogloea ramigera*.

*Zoogloea ramigera* Itzigsöhn has the following characters:

(1) Colonies of a gelatinous nature of various shapes, usually described as branched or lobed (see Zopf's figures) but I have frequently observed them as unlobed spherical masses.

(2) Individual cells small (2 × 0·5 $\mu$), well marked, with homogeneous contents not arranged in filaments but embedded in a gelatinous matrix.

This usually occurs in waters where the organic matter is very plentiful.

Like *Cladothrix dichotoma*, the systematic position of *Zoogloea* is a matter of doubt. Zopf(33) includes it with *Cladothrix dichotoma*, but more recently Blöch(3) on the grounds of culture work considers it to be an independent species and refers it to the genus *Bacterium* as *B. Zoogloea ramigera* (Itzig.) Blöch.

It is well known, however, that many bacteria form zoogloea stages under certain cultural conditions, and conceivably organisms named *Zoogloea ramigera* may represent such stages of several different bacteria found in organic effluents. It would be difficult to identify these except by isolation in pure culture and subjection to the usual bacteriological tests. Indirect evidence suggests that a certain amount of the *Zoogloea* of the sewage-fungus community is an extreme form of *Sphaerotilus*, as it never occurs in anything approaching pure cultures, and intermediate forms (*e.g.* var. *transiens*) are not infrequent. Threads of *Sphaerotilus natans* often grow from the gelatinous masses of *Zoogloea ramigera*, but it is difficult to decide by microscopic examination whether such filaments are epiphytic on the *Zoogloea* or actually growing out from the colony.

*Beggiatoa alba* (Vauch.) Trevis.
*Beggiatoa punctata* Trevis.(28).
*Oscillaria alba* Vauch.(30).

Although characteristic of waters rich in sulphur compounds this species sometimes occurs in the sewage-fungus community (see Kossowicz(20)).

Its general characters are:

(1) Filaments free, unbranched, with very fine transverse walls.

(2) Growths usually in the form of thin whitish films—definite colonies like those of *Sphaerotilus* rarely found.

(3) Cells rod-shaped 3–4 × 1–2 $\mu$, when young well-defined and distinct within the filament. The cells of the old filaments lose their form and are often filled with large granules of sulphur which give a grey or nearly black colour to the filaments when viewed under a low power of the microscope.

A more detailed description of sulphur bacteria is given by Winogradsky (31) and Bavendamm (2).

*Leptomitus lacteus* Agardh (1).

*Apodya lactea* Cornu (9).

This is a typical Phycomycete (Saprolegniales) with branched non-septate hyphae 7 $\mu$ wide, constricted at intervals, usually near the branches. The contents are granular and there are also characteristic (cellulose) bodies just below each constriction. Reproduction is apparently usually by zoospores and sexual reproduction seems to be rare.

*Leptomitus* forms tufts similar to those of *Sphaerotilus natans* var *vulgaris*, but because of the absence of a mucilaginous investment to the hyphae, colonies are not slimy but feel rather like cotton-wool.

*Fusarium aquaeductum* (Radl. & Rab.) Sacc. (26).

*Selenospora aquaeducta* Radlek. & Rabenhorst (25).

This is one of the Fungi Imperfecti and is rather rare, usually occurring in acid waters. The hyphae are coarse (5 $\mu$ wide), branched and septate, the average length of cell being 50 $\mu$. The crescent-shaped conidia characteristic of the genus are sometimes produced, but mostly there are no reproductive bodies and in this state it is almost impossible to distinguish it from other septate fungi such as *Penicillium fluitans* Tiegs which so far is not recorded for this country.

*Fusarium aquaeductum* forms growths similar to those of *Sphaerotilus natans* var. *vulgaris* or *Leptomitus lacteus*, but they are coarser, less mucilaginous and often possess a pink tint.

*Carchesium spectabile* Ehrenb. and *Carchesium Lachmanni* Clap. & Lach. (7) em. S. Kent (16).

These ciliate Protozoa form snow-white fungus-like growths resembling those of the organisms just described and because of this character they are included in the definition of sewage-fungus community outlined above. This is the only genus of colonial vorticellids that has been observed in this community. Their microscopic appearance is characteristic and unmistakable. The genus is distinguished by the branched stalks and by the central nerve column being discontinuous through the node of each branch. Two closely allied species, *Carchesium spectabile* and *C. Lachmanni*, have been observed,

and a summary of their chief characters mainly taken from Saville Kent(16) is as follows:

*Carchesium Lachmanni* Clap. & Lach.(7). Individuals elongate, conical or thimble-shaped, anterior end truncate and not dilated, pyriform and plicate when contracted. Macronucleus curved, placed parallel to the longitudinal axis and presenting numerous sinuosities. Colony branching in a subumbellate manner.

*Carchesium spectabile* Ehrenb. Individuals broadly campanulate, anterior end truncate or dilated, subsphaeroidal when contracted. Macronucleus curved, placed parallel to the longitudinal axis but rarely sinuous. Colony dense, bushy, obliquely conical.

## Table I. *Records of sewage fungi*

*Sphaerotilus natans.*

var. *typica.*

Colwick, Trent, beet-sugar factory; Newcastle-under-Lyme, Lyme Brook, domestic sewage; Bury St Edmunds, Lark, beet-sugar factory; Peterboro', Nene, beet-sugar factory; Cantley, Yare, beet-sugar factory; Wareham, Piddle, domestic sewage; Ivybridge, Erme, paper mills, domestic sewage.

var. *Cladothrix.*

Croft Spa, Tees, domestic sewage; Barnard Castle, Tees, domestic sewage; Ilkley, Wharfe, domestic sewage; Leeds, Aire, very mixed; Wakefield, Calder, very mixed; Colwick, Trent, beet-sugar factory; Newcastle-under-Lyme, Lyme Brook, domestic sewage; Ely, Great Ouse, beet-sugar factory; Hilgay, Wissey, beet-sugar factory; Mildenhall, Lark, beet-sugar factory; Lackford, Lark, sewage effluent; Shelford, Cam, paper mill, glue factory; Chesham, Chess, domestic sewage; Hemel Hempstead, Gade, paper mill; Felstead, Chelmer, beet-sugar factory; Atherstone, Stour, domestic sewage; Wareham, Piddle, domestic sewage; Bodmin, Camel, domestic sewage; Wellington, Tern, beet-sugar factory; Carlow (Ireland), Barrow, beet-sugar factory.

var. *vulgaris.*

Croft Spa, Tees, domestic sewage; Barnard Castle, Tees, domestic sewage; Ilkley, Wharfe, domestic sewage; Leeds, Aire, very mixed; Wakefield, Calder, very mixed; Colwick, Trent, beet-sugar factory; Newcastle-under-Lyme, Lyme Brook, domestic sewage; Bury St Edmunds, Lark, beet-sugar factory; Mildenhall, Lark, beet-sugar factory; Lackford, Lark, sewage effluent; Peterboro', Nene, beet-sugar factory; Cantley, Yare, beet-sugar factory; Needham Market, Gipping, artificial silk (viscose process); Shelford, Cam, paper mill, glue factory; Chesham, Chess, domestic sewage; Hemel Hempstead, Gade, paper mill; Bodmin, Camel, domestic sewage; Erme, Ivybridge, paper mills, domestic sewage; Wellington, Tern, beet-sugar factory; Carlow (Ireland), Barrow, flour mills.

*Zoogloea ramigera.*

Colwick, Trent, beet-sugar factory; Ely, Great Ouse, beet-sugar factory; Hilgay, Wissey, beet-sugar factory; Bury St Edmunds, Lark, beet-sugar factory; Peterboro', Nene, beet-sugar factory; Cantley, Yare, beet-sugar factory; Wellington, Tern, beet-sugar factory.

*Leptomitus lacteus.*

Wakefield, Calder, mixed; Bury St Edmunds, Lark, beet-sugar factory; Peterboro', Nene, beet-sugar factory; Wellington, Tern, beet-sugar factory; Carlow (Ireland), Barrow, beet-sugar factory.

*Fusarium aquaeductum.*

Bradford, sewage outfall, sewage after acid extraction of fat; Burton, Trent, brewery; Hilgay, Wissey, beet-sugar factory; Bury St Edmunds, Lark, beet-sugar factory; Needham Market, Gipping, artificial silk (acetate process).

*Carchesium* spp.

Croft Spa, Tees, domestic sewage; Leeds, Aire, mixed; Wakefield, Calder, mixed; Lackford, Lark, sewage effluent; Chesham, Chess, domestic sewage; Atherstone, Stour, domestic sewage.

General distribution and ecology of the various species

Table I shows the chief records I have made of the distribution of the members of the sewage-fungus community in this country. The chief facts established by this table and by the account given by me (Butcher, Pentelow and Woodley(6)) of its occurrence in the River Lark are:

(1) The community is to be found wherever there is a sufficient quantity of certain forms of organic matter.

(2) This organic matter may be supplied by waste waters from any of the following: artificial silk factories, beet-sugar factories, breweries, flour mills, glue factories, jam factories, paper mills, as well as by domestic sewage and, in Germany, by slaughter houses (Tiegs(27)) and cellulose factories (Heiduschka & Munds(14)).

(3) The list suggests that some organic compound derived from, and common to, both plant and animal proteins is necessary for the growth of the community.

(4) The development of the community is not dependent on the amount of oxygen in the water.

(5) The commonest species is *Sphaerotilus natans*.

Further indication of the nature of the organic substances present in the effluents which promote growth may be gleaned from papers describing the behaviour in pure culture of the various species. These are on *Cladothrix dichotoma* (Linde(22)) *Sphaerotilus natans* (Zikes(32)), *Zoogloea ramigera* (Blöch(3)) and *Leptomitus lacteus* (Trommsdorff(29)). It is shown that all these organisms grow well in certain concentrations of meat broth and peptone water. *Sphaerotilus* and *Cladothrix* grow well in a 0·001 per cent. solution, but *Zoogloea* does not grow in dilutions greater than 1 per cent. (Blöch). Growth of all four organisms can be obtained in organic nitrogen compounds such as egg albumin. Their reactions to other nitrogenous compounds differ. With amino acids alone there is no growth with *Sphaerotilus* and *Cladothrix*, but if a small quantity of sugar be added to the medium there is rapid growth; *Leptomitus*, however, will grow well without the addition of sugar. The same results are obtained with ammonium salts and nitrates, except that *Sphaerotilus* grows slightly without the addition of sugar, though this growth is considerably increased by adding sugar. Growth of *Leptomitus* in solutions of ammonium salts is considerably augmented by the addition of calcium carbonate, probably because the calcium prevents the medium from becoming acid.

These data show why growth can be promoted by all the above effluents; namely, that they either contain organic nitrogen compounds (which can by themselves bring about the growths) or carbo-

hydrates which in conjunction with ammonium salts and nitrates already in the river can also promote growth.

The natural occurrence of the various species is outlined below.

### I. *Occurrence of the* Sphaerotilus natans *group*

*Sphaerotilus natans* and its varieties may be found in either soft or hard waters polluted by a large amount of organic matter, with a *p*H from 6·0 to 8·0, a low sodium chloride content and a current not less than 20 cm. sec. (Kolkwitz(18)). Since the majority of polluted river waters in this country exhibit such characters *Sphaerotilus natans* is widely distributed. All the varieties described, however, may occur in the same river. The var. *vulgaris* is always present and sometimes (*e.g.* below beet-sugar factory effluents) forms pure growths; var. *Cladothrix* is generally associated with it, if branched threads be taken as a criterion for the occurrence of this form. Where the concentration of organic matter is great, *Zoogloea ramigera* occurs. This may possibly be *Sphaerotilus natans* or various bacteria in the form of zoogloea, or it may be a distinct species, the evidence for either side being not yet conclusive. In addition, in such places there can often be found vars. *transiens*, *prolifera* and *typica*. Where the organic matter is more dilute or partially decomposed, vars. *depauperatus* and *Cladothrix* occur, the latter in such places being often the only variety present.

### II. *Occurrence of other forms*

(*a*) *Carchesium* spp.

When the source of organic matter is sewage there are always species of *Carchesium* present, sometimes in considerable quantity. Other Protozoa invariably occur in such places, but they do not form colonies which exhibit macroscopically the fungus-like appearance of the species of *Carchesium*. The conditions of existence of the species of *Carchesium*, except that they occur below sewage outlets, have not been studied.

(*b*) *Leptomitus lacteus*.

The occurrence of members of the sewage-fungus community other than *Sphaerotilus natans* and the species of *Carchesium* is, in this country, under exceptional rather than usual circumstances. The most frequent of these rarer forms is *Leptomitus lacteus* which seems to be more widely distributed on the Continent than in England. All the records both in England and abroad appear to be from places where the organic matter is very small, or where an organic effluent enters a river and becomes immediately greatly diluted. Thus, this fungus was observed in condenser water in the beet-sugar factories of Peterborough and Bury St Edmunds. It also occurred in the River Tern under the following circumstances: in 1927 when the beet-sugar factory on its banks commenced operations the season was exception-

ally wet and as a result the river remained very full and flooded throughout the winter. The chief fungus present was *Leptomitus*. In the following year, when the river was at normal level, almost the only member of the sewage-fungus community growing in the river was *Sphaerotilus natans*. There can be little doubt that the effluents were more highly diluted in 1927 than in 1928, and this higher dilution was responsible for the appearance of *Leptomitus* in the first year. Exactly the same sequence of events took place in the River Barrow in Ireland during the same two years.

(*c*) *Fusarium aquaeductum.*

The following records show that this form occurs chiefly in acid waters:

(1) The settling pit of a beet-sugar factory where the water had a *p*H of 3·5 due to lactic and butyric acid fermentations.

(2) The River Gipping below an artificial silk factory where the acetate process was being used and the *p*H was 5·0.

(3) One of the channels conveying an effluent from the Bradford Sewage Works which had been subjected to a treatment with sulphuric acid in order to extract the fats from the sewage, and this kept the effluent acid.

(4) Occasionally in parts of the River Lark, and especially in a ditch nearest a beet-sugar factory where the effluent tended to lower the *p*H of the natural water below 7·0.

(*d*) *Beggiatoa alba.*

*Beggiatoa* normally occurs in sulphur springs and similar places, but has also been found in polluted waters. The only record I have made is in the outlets of sewers in the estuary of the Tees, but Ellis (13) has observed it in the Clyde estuary. It is significant that in both localities the salinity of the water is high. As is known (Butcher, Pentelow and Woodley (6); Busgen (4)), sodium chloride seems to inhibit the development of *Sphaerotilus natans*, and the absence of this species may enable *Beggiatoa* to develop. That *Beggiatoa* occurs only in the foulest waters as stated by Mez (23) is not borne out by my investigations.

Undoubted specimens of *Penicillium fluitans* (Tiegs (27)) have not yet been recorded in this country, though the septate mycelia of various fungi without reproductive bodies occur, not infrequently, in polluted acid waters.

## III. *Relation of the sewage-fungus community to the organic pollution of rivers*

As abundant previous records both in this country and on the Continent have shown, organic pollution is invariably responsible for the occurrence of sewage fungus, and this is amply confirmed by

the facts given above. Many of the suggested causal relations of the different members to the environment have already been confirmed by experimental culture, and one can indicate to a certain extent the constituents of the organic matter that cause the growth.

First, proteins and similar organic compounds can by themselves bring about growth of all the organisms, but as these rapidly decompose to ammonium compounds growth soon ceases. This is probably so with domestic sewage. If, in addition, carbohydrates are also present, or carbohydrates be added to a water with high ammonia or nitrate content, growth, especially of *Sphaerotilus*, is again encouraged. Further, as these carbohydrates are more stable than organic compounds from sewage, conditions favourable to growth can obtain along a much longer stretch of river. The Lark and Ouse are excellent examples of this. The effluent responsible came from a beet-sugar factory. In the Ouse, growth of *Sphaerotilus* was observed for over thirty miles, in the Lark for about twenty, this being out of all proportion to the amount of organic matter in these effluents as compared to a sewage effluent. This fact also indicates the causal factor in a great many other industrial effluents.

As *Leptomitus* will grow without this addition of sugar it may be found in waters polluted with nitrogenous compounds alone, especially if rich in calcium carbonate (Trommsdorff, *loc. cit.*). In this country, however, the appearance of *Leptomitus* is too spasmodic to suggest the true causal factors; the state of decomposition of the organic matter alone does not appear to be the sole reason.

Where the water becomes acid species other than *Sphaerotilus* and *Leptomitus* occur, as, for example, *Penicillium fluitans* (Tiegs(27)) and *Fusarium aquaeductum*.

The appearance of sewage fungus in quantity is always linked up with other obvious chemical and biological indications of gross pollution such as foul smell, deficiency of oxygen, abundance of ammoniacal nitrogen and the paucity of the fauna. A slight growth may be detected, however, even where a stream is by other tests, apparently unpolluted, occurring as a growth upon the algae (especially filamentous species like *Cladophora*) or upon glass slides placed on the river bed.

## IV. *Variations in the quantity of organic matter in relation to the distribution of sewage fungus*

When organic effluents enter a river there is an immediate dilution which becomes greater as the waters pass downstream, while, simultaneously, decomposition of the organic matter is taking place. The rate of decomposition increases with the rise of temperature, and organic matter, which in the winter may be carried ten miles down

a river before its breakdown is complete, will be totally decomposed in the first mile during high temperatures.

Sewage fungus therefore will grow over a longer stretch of river in winter than in summer, and this fact has led to the organisms being regarded as winter forms. Their development is, however, in no way dependent on low temperatures; in the River Lark growth was just as prolific near the factory where the average temperature of the water during November was 15° C., as at Lackford where the average temperature was 6° C. The optimum of the various species is between 25 and 30° C. according to Blöch, Zikes, and Linde.

Below an effluent the following succession of forms occurs as one passes downstream, and therefore with the decreasing quantity of undecomposed organic matter.

*Zoogloea ramigera* → { var. *transiens* / var. *prolifera* } → var. *typica* → var. *vulgaris*
→ var. *Cladothrix* → var. *depauperatus*.

In nature it is unusual to get dilution without much decomposition, but where this is retarded the optimum conditions for the development of *Leptomitus* instead of *Sphaerotilus* seem to be realised. The large rivers of the Continent result in greater dilution of organic effluents, and so the more frequent occurrence of *Leptomitus lacteus* may be correlated with dilution rather than with the state of decomposition of organic matter as suggested by Tiegs (27). Indeed, if decomposition was the factor one would expect to find *Leptomitus lacteus* at the downstream end of a stretch of river containing *Sphaerotilus natans* and this I have never observed.

The observations here recorded were made in the course of investigations on river pollution for the Ministry of Agriculture and Fisheries and I wish to express my thanks to the Department for permission to publish this paper.

## EXPLANATION OF PLATE III

Fig. 1. *Sphaerotilus natans* var. *vulgaris* from River Tern. × 600.
Fig. 2. *Sphaerotilus natans* var. *vulgaris* (granular contents well developed) from River Lark. × 1000.
Fig. 3. *Sphaerotilus natans* var. *Cladothrix* from River Tees. × 1000.
Fig. 4. *Sphaerotilus natans* var. *prolifera* from River Lark. × 600.
Fig. 5. *Sphaerotilus natans* var. *depauperatus* from River Lark. × 1000.
Fig. 6. *Sphaerotilus natans* var. *transiens* from River Lark. × 600.

## REFERENCES


(1) Agardh, J. G. *Species Algarum* (1824), p. 47.
(2) Bavendamm, W. "Schwefelbakterien." *Pflanzenforschung*, Heft 2 (1924).
(3) Blöch, M. "Beiträge zur Untersuchung über die *Zoogloea ramigera* Itzigsöhn auf Grund von Reinkulturen." *Centr. für Bakt.* Abt. 2, xlviii(1918), 44.
(4) Busgen, M. "Kulturversuche mit *Cladothrix dichotoma*." *Ber. d. Deutsch. Bot. Gesellsch.* xii (1894), 147.
(5) Butcher, R. W. "Biological changes brought about by sewage in small streams." *Proc. of Ass. of Managers of Sewage Disposal Works*, Kew (1928).
(6) Butcher, R. W., Pentelow, F. T. K. and Woodley, J. W. A. "An investigation of the River Lark and the effect of beet-sugar pollution." *Fishery Invest.* Series 1, iii, No. 3 (1930).
(7) Claparède, H. and Lachmann, L. *Études sur les Infusoires*. Paris (1868).
(8) Cohn, F. J. *Beitr. z. Biol. der Pflanz.* 1 (1875), 185.
(9) Cornu, F. *Acad. Science Nat.* Series 5, xv (1872), 14.
(10) Ellis, D. "An investigation into the life-history of *Cladothrix dichotoma*." *Proc. Roy. Soc.* B, lxxxv (1911), 344.
(11) —— *Iron Bacteria*. London (1919).
(12) —— "Methods of estimating pollution in tidal estuaries and water reservoirs." *Journ. Brit. Waterworks Assoc.* Circular 69 (1927).
(13) —— "A bacteriological investigation into the state of the pollution of the River Clyde." *Journ. Roy. Tech. Coll. Glasgow* (1929), p. 129.
(14) Heiduschka, A. and Munds, E. "Studien über die Abwasser der Cellulosefabriken." *Zeitsch. für Angew. Chem.* xlii (1929), 11.
(15) Höflich, K. "Kultur u. Entwicklungsgeschichte der *Cladothrix dichotoma*." *Oesterr. Monatsschrift für Tierheilkunde*, xxv (1901).
(16) Kent, W. Saville. *Manual of the Infusoria*, London, ii (1881), 691.
(17) Itzigsöhn, H. in *Sitzungsber. der Gesellsch. Naturf. Freunde zu Berlin* (1867). Berlin, 1868.
(18) Kolkwitz, R. *Kryptogamflora der Mark Brandenburg*. V. *Schizomycetes, Spaltpilze, Bacteria*. Berlin (1909).
(19) Kolkwitz, R. and Marsson, M. "Oekologie der Saprobien." *Ber. d. Deutsch. Bot. Gesellsch.* xxix (1911), 386.
(20) Kossowicz, A. *Mykologie der Gebrauchs- und Abwasser*. Berlin (1913).
(21) Kützing, F. T. *Linnaea*, viii (1833), 385.
(22) Linde, P. "Zur Kenntnis von *Cladothrix dichotoma*." *Centr. für Bakt.* Abt. 2, xxxix (1913), 369.
(23) Mez, W. *Zeitsch. d. deutschen Zuckerindustrie* (1899), p. 674.
(24) Migula, W. *System der Bacterien*, Jena, ii (1900), 1033.
(25) Radlekofer, L and Rabenhorst, L. *Hedwigia*, ii (1863), 73.
(26) Saccardo, S. *Sylloge Fungorum*, x (1892), 728.
(27) Tiegs, E. "Beiträge zur Oekologie der Wasserpilze." *Ber. d. Deutsch. Bot. Gesellsch.* xxxvii (1919), 498.
(28) Trevisan, V. B. A. *Flora Euganea* (1842), p. 56.
(29) Trommsdorff, R. "Ueber die Wachstumbedingungen der Abwasserpilze *Leptomitus* und *Sphaerotilus*." *Centr. für Bakt.* Abt. 2, xlviii (1918), 62.
(30) Vaucher, J. P. E. *Histoire des Conferves d'eau douce*. Genève (1803).
(31) Winogradsky, S. "Beiträge zur Morphologie und Physiologie der Bakterien. I." *Zur Morphologie und Physiologie der Schwefelbakterien*. Leipzig (1888).
(32) Zikes, H. "Vergleichende Untersuchungen über *Sphaerotilus natans*." *Centr. für Bakt.* Abt. 2, xliii (1915), 529.
(33) Zopf, W. *Zur Morphologie der Spaltpflanzen*. Leipzig (1882).

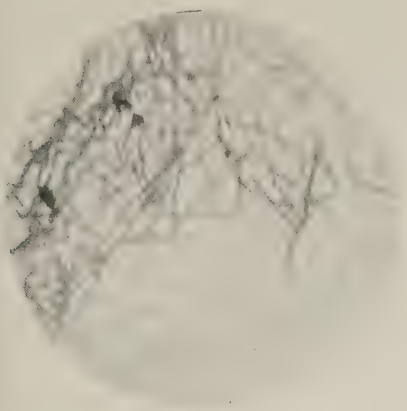


Fig. 1

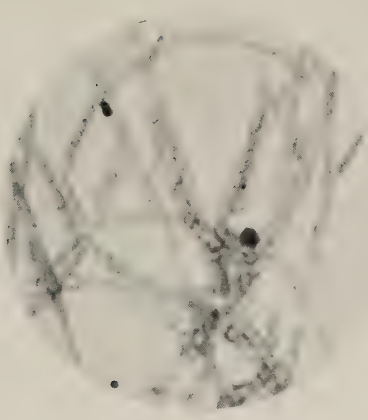


Fig. 2

Fig. 3

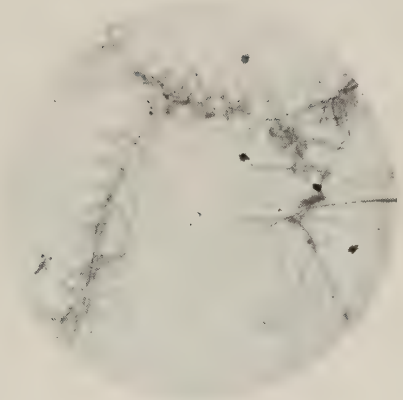


Fig. 4

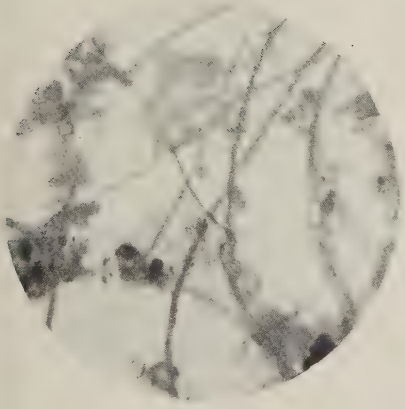


Fig. 5

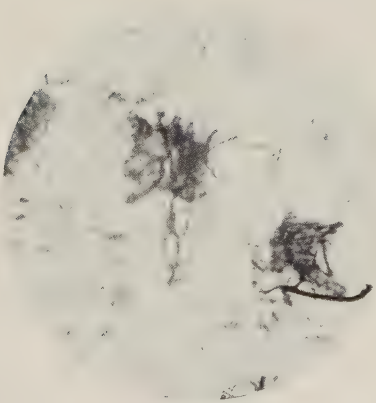


Fig. 6

# BRITISH XYLARIACEAE. II*

By JULIAN H. MILLER, Ph.D.

(With Plates IV–VI, and 1 Text-figure)

Since publishing the first paper(5) on this subject I have had an opportunity of studying the specimens in the Herbarium of the Royal Botanic Gardens, Kew, and have found there four additional species, and have obtained a further one through Mr E. W. Mason. Descriptions of these species will be given here, and the diagnosis of the genus *Nummularia* Tul. will be emended.

1. ***Hypoxylon Howeianum*** Pk. in *24th Rep. N.Y. State Mus.* (1871), p. 98.
   ? *Sphaeria enteromela* Schw. in *Journ. Acad. Nat. Sci. Phila.* v (1825), 10
   ? *Hypoxylon commutatum* Nits. *Pyr. Germ.* (1867), p. 33.
   ? *H. enteromelum* (Schw.) Berk. in *Grev.* iv (1875), 51.
   *H. multiforme* Fr. var. *australe* Cke. in *Grev.* xi (1883), 129.

Type: Original collection of C. H. Peck in New York State Museum, Albany, N.Y.

(Pl. IV, figs. 1–3)

Stroma globose to hemispherical and symmetrical except when crowded, then tending to coalesce, but never widely effused, 3–12 mm. in diameter and 3–8 mm. thick, erumpent from bark or from decorticated wood; ectostroma bright brick-red, varying to reddish purple or brown and in old age darkening to almost black; entostroma satiny black with one or more faint concentric zones, fleshy-leathery to woody in texture, never carbonaceous; perithecia in periphery of stroma, opening by umbilicate ostiola which do not protrude beyond the ectostroma. Asci elongate, cylindric, spore part 50–60 $\mu$ in length and stalk 40–50 $\mu$; ascospores at maturity inequilaterally elliptical, almost opaque, 6–9 × 3–3·5 $\mu$.

Conidia borne on surface of ectostroma, hyaline, 4–6 $\mu$ in diameter, globose to oblong.

On various deciduous trees. Peck's type is on *Pyrus Malus*; also found on *Quercus*, *Fraxinus*, *Carpinus*, *Corylus*, *Ostrya* and *Alnus*. This species is apparently common all over the world, but is more abundant in the region just south of that inhabited by *Hypoxylon coccineum*, in the southern north-temperate zones. I have seen no specimens of the

* The writer is indebted to the Director of the Royal Botanic Gardens, Kew, Miss E. M. Wakefield of that Institution, Mr E. W. Mason of the Imperial Mycological Institute, Dr E. Hannig of the Botanic Institution at Münster, Dr J. A. Nannfeldt at Upsala, and Dr W. J. Lütjeharms at the 'Rijks Herbarium of Leiden, for so generously making available specimens and facilities to work.

latter species from the tropics, and it is probable that such references have actually been based on specimens of *H. Howeianum*.

The specific name *Howeianum* is selected because it is the first one given in which the diagnosis and type specimen contained characters that would separate the fungus from the closely allied species *H. coccineum*. The spore measurements and the hosts are the most distinctive characters. Schweinitz gave no spore measurements, and an authentic specimen in Kew labelled *Sphaeria enteromela* L. v. S. is young and without spores and seems to be on *Fagus*.

The specimen cited by Nitschke as the type of *H. commutatum* is Fuckel Fung. Rhen. no. 1056*a*, on *Carpinus*. This is sterile and so indeterminable. In his diagnosis he gives a spore length of 12 $\mu$ for both this species and for *H. coccineum*, which is exactly a mean between the measurements of the two. The only sure specimen in his herbarium is one labelled in his handwriting *H. coccineum* Bull. Therefore, it seems logical to discard Nitschke's name.

In Europe *H. Howeianum* might be confused with *H. rutilum* Tul., but the latter is distinct in that it is pulvinate tending to be effused, with slightly papillate ostiola; and is very small, rather than large-globose or semi-globose as is typical of the former. In the key this one should go with *H. coccineum*, differing in the hosts and smaller ascospores.

*Material examined*

Peck's specimen in New York State Museum, Albany, N.Y., on *Pyrus Malus*.

Fuckel Fung. Rhen. no. 2176, on *Carpinus*. Herb. Kew. no. 174, under *H. commutatum* Nits., determined Fuckel.

Fuckel Fung. Rhen. no. 1056*a*, on *Carpinus*, sterile. Herb. Nitschke, Münster.

Reader no. 21, Australia. Herb. Kew. no. 165, under *H. rutilum* Tul. Determined Massee.

Plowr. Sphaer. Brit. Cent. 2, no. 12, 1875. Hereford, Herb. Kew. no. 175, under *H. coccineum*. Later Massee wrote "*commutatum*" on it.

Nits. 10–'66, Wolbeck, on *Salix caprea*, under *H. coccineum*.

J. B. Ellis, no. 2842, Fung. of N.J., on *Quercus*, March, 1874. Herb. Kew. no. 155.

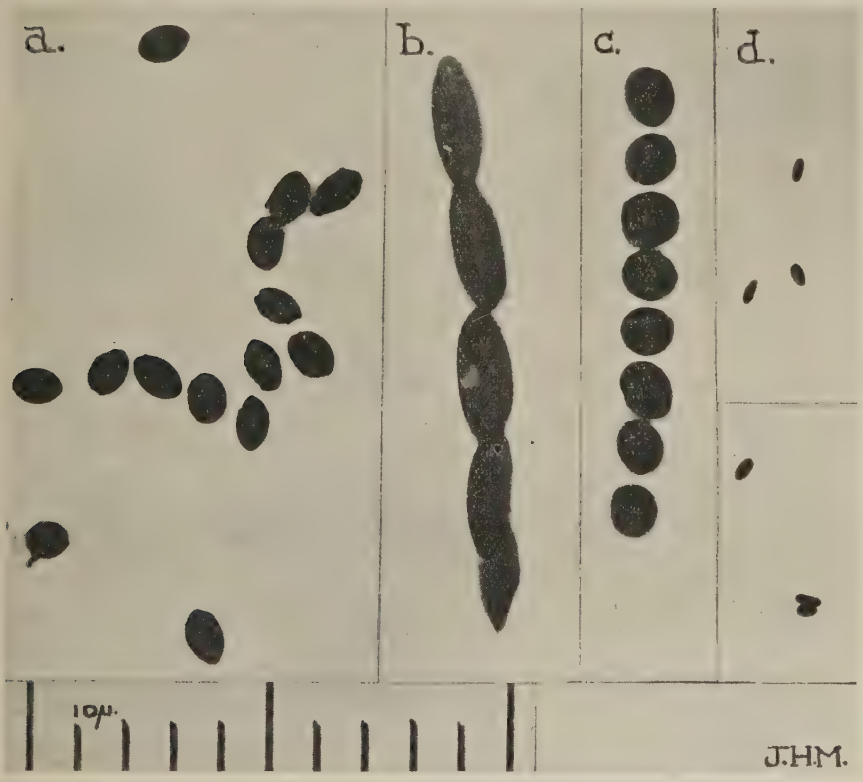
Rel. Farl. no. 38, Mass., under *H. Howeianum* Pk. Herb. Kew. no. 157.

2. ***Hypoxylon udum*** Fr. *Summa Veg. Scand.* (1849), p. 384.
*Sphaeria uda* Fr. *Syst. Myc.* II (1823), 358. Non Persoon.
Type: Fries, Scler. Suec. no. 324 at Upsala.

(Pl. V, figs. 1–3)

Initial stromal layer dirty white to light grey, byssoid, perithecia developing under this; mature stroma black, carbonaceous, plainly

showing the perithecial forms, small orbicular to oblong, consisting of a single row of perithecia united by the covering ectostroma, or 2–4 mm. wide by 10–15 mm. long. On very soft wood the perithecia are almost immersed and on hard decorticated wood superficial; ostiola distinctly papillate; asci cylindric, 140–180 $\mu$ in length for the




Text-fig. 1. Photomicrographs of ascospores of the following species: (*a*) *Hypoxylon nummularium*. Moug. & Nestl. St Vog.-Rhen. no. 374. (*b*) *Hypoxylon udum*. Herb. Kew. no. 1195. (*c*) *Nummularia discreta*. Schweinitz spec. Herb. Kew. no. 1438. (*d*) *Hypoxylon stygium*. Léveillé type, Museum Bot., Paris.

The scale is taken from the stage micrometer with the same camera and microscope combinations as for the spores.

spore part and 30–50 $\mu$ for the rather short stipe; ascospores oblong, navicular to slightly fusoid, dark brown at maturity, 26–34 × 9–11 $\mu$ (Text-fig. 1 *b*).

The stroma closely resembles that of *H. semiimmersum* Nits., but this species is easily separable by the much larger ascospores; also the ascospore is rather narrowly navicular, while that of *H. semiimmersum* is broadly fusoid.

On *Quercus* species. Not common in Europe and British Isles.

The American form approaching *H. udum* has the same length of spore, but broadly fusoid, 12–20 $\mu$ in width, and so is probably distinct. I have seen no American specimen which seemed to be identical with those from Europe.

The specific name *udum* should be discarded according to a strict interpretation of the International Rules, Art. 16 *bis*, 1930. Fries obtained his name from Persoon, and cited the latter under *Sphaeria uda* in *Syst. Myc.* p. 358, and since the publication of *Summa Vegetabilium Scandinaviae* by him, this species has been written *H. udum* (Pers.) Fr. The type should be the specimen of Persoon, and not of Fries, and I find that the only specimen labelled *Sphaeria uda* Pers. in Persoon's herbarium is *Hypoxylon serpens*; therefore the name is invalid as it constitutes a later homonym. However, as the Fries's specimen cited above is correct for usage since 1849 by such mycologists as Nitschke, Berkeley, Saccardo and others, it seems best to conserve the name *udum* for this form.

*Material examined*

Herb. Kew. no 1208, under *Sphaeria uda* Pers. Wothorpe, Sept. 1857. Herb. Berk.

Rehm Ascom. no. 78, on *Quercus*. Herb. Kew. no. 1195. Also in N.Y. Bot. Gard. and in 'Rijks Herb. Leiden.

Fr. Scler. Suec. no. 324. Two specimens in Herb. Kew. nos. 1204 and 1210. Also same number at Upsala. Compared Nannfeldt.

De Thüm. Myc. Univ. no. 1265, on *Quercus*, 1879. Herb. Kew. no. 1214.

Roum. Fung. Sel. Ex. 5025, 1889. Herb. Kew. no. 1215. Also in Cornell Herb.

Karsten Fung. Fenn. Ex. 561, 1866. Herb. Kew. no. 1221.

Fuckel Fung. Rhen. no. 2177, on *Quercus*, under *H. semiimmersum*. Herb. Kew. no. 1275.

3. ***Hypoxylon nummularium*** Bull. ex Fr. *Summa Veg. Scand.* (1849), p. 384.

*H. nummularium* Bull. *Champ. Fr.* I (1791), 179, tab. 468, fig. 4.
*Sphaeria nummularia* DC. *Flor. Fr.* II (1805), 290.
*S. anthracina* Schm. & Kunze *Mycol.* Heft. I (1817), 55, tab. 2, fig. 14.
*S. nummularia* Bull. ex Fr. *Syst. Myc.* II (1823), 348.
*Nummularia Bulliardi* Tul. *Sel. Carp.* II (1863), 43, tab. 5, figs. 11–19.
*N. anthracina* (Schm. & Kun.) Schroet, *Krypt.-Fl. Schles.* III (1897), 2, 458.
*N. Bulliardi* Tul. var. *minor* Rehm no. 277, Tranzsch. et Serebrianikow, *Myc. Rossica* (1911).
*Numulariola nummularia* (B. ex Fr.) House in *Rep. N.Y. State Mus.* 266 (1925), p. 49.

Type: Bulliard's fig. 4 in reference cited above.

(Pl. V, fig. 4.)

Stroma widely effused, applanate, slightly convex, depending on the curvature of the wood on which it is growing, erumpent from bark or on decorticated wood, light brown to black at maturity; ectostroma very hard, carbonaceous, entostroma not well developed; perithecia borne in periphery of stroma, globose to elongate when closely packed, ostiola minutely papillate exserted, blunt, usually open, perforated; asci cylindrical with short stipe, 100–125 $\mu$ long by 10–12 $\mu$ wide, with long scarcely branched paraphyses. Ascospores elliptical to almost globose with rounded ends, 11–14 × 7–10 $\mu$, opaque when old (Text-fig. 1 *a*).

A reddish brown conidial layer at first covers the ectostroma, later peeling off exposing the black mature surface.

On *Fagus*, probably rare in England, but more common on the Continent.

This species is easily separable from other species of *Hypoxylon*. Here the stroma rarely becomes pulvinate, or separates into individual perithecia, while in flat forms of *H. serpens* or *H. rubiginosum* one can usually find this stromal diversity. The only other European form approaching this is *H. mediterraneum* (de Not.) Mill., and this differs in the possession of large papillate ostiola and much larger ascospores. I have specimens of the last species from Holland, Germany and France, but not from the British Isles.

*Material examined*

A. W. Bartlett, April, 1912, Worthing, on *Fagus*. Mason Herb. no. 1166.

A. W. Bartlett, Thorpe Wood, Kiveton Park, probably on *Fagus*, April 1924. Mason Herb. no. 1165.

Moug. et Nestl. Stirp. Vog.-Rhen. no. 374, on *Fagus*. Herb. Kew. no. 1388. Also in Cornell Herb.

Persoon specimen no. 910, 269–132, 'Rijks Herb. Leiden.

Fuckel Fung. Rhen. no. 1062, on *Fagus*. Herb. Kew. no. 1412.

Tranzsch. and Serebr. *Myc. Rossica*, no. 277, on *Fagus*, 1911. Herb. Kew. no. 1409.

Rabh.-Wint. Fung. Eu. no. 2956, on *Fagus*, 1883. Herb. Kew. no. 1401.

4. ***Hypoxylon stygium*** (Lév.) Sacc. *Syll. Fung.* 1 (1882), 379.

*Sphaeria stygia* Lév. in *Ann. Sci. Nat.* v (1846), 258.

*Hypoxylon Puiggarii* Speg. in *Bol. Acad. Cient. Corboba*, xi (1889), no. 257.

*H. annuliforme* Rehm in *Verh. bot. Ver. Brand.* (1890), p. 65.

*H. platystomum* E. &. E. *N.A. Pyr.* (1892), p. 649.

*H. microcarpum* Penz. & Sacc. in *Malphigia*, II (1897), 492.
*H. bogoriense* von Höhn. in *Sitzb. K. Ak. d. Wiss. Wien*, 118 (1909), abt. I, p. 341.
*H. punctatum* Petch in *Ann. Roy. Bot. Gard. Peradeniya*, VIII (1924), 153.

Type: Specimen in Herb. Mus. Paris, from St Dominique, leg. Poiteau.

(Pl. VI, figs. 1–3)

Stroma originating as a very thin reddish brown layer when under moist conditions, or a reddish slate colour if exposed, gradually darkening until at maturity it is shining black, hard and carbonaceous. The perithecia arise under the thin ectostroma, and the vertices grow through this layer in the form of a ring, in the centre of which is found the small papillate, conical ostiolum. When the perithecia are very crowded in the stroma they are very minute, but when far apart they are almost as large as those of *H. truncatum* (Schw.) Mill. Ascospores oblong to navicular at maturity, dark brown, 5–8 × 2·5–3 $\mu$ (Text-figure 1 *d*).

This form has the smallest perithecia and ascospores found in the annulate group. It is quite disconcerting in its many variations. The red initial form is the *H. platystomum* of Ellis, or *H. bogoriense* of von Höhnel. The mature effused form was referred to *H. marginatum* by Berkeley, and the large number of specimens in the Kew Herbarium so named are this species. *H. truncatum* (syn. *H. marginatum*) has often been confused with *H. stygium*. Both are annulate, having the same appearance at maturity, but *H. stygium* differs in its smaller perithecia and ascospores and in the colour of the initial layer. Very old specimens with perithecia not close together, sometimes have spores almost as large as those of *H. truncatum*. The juvenile form is red in *H. stygium*, and green in *H. truncatum*.

The only specimens collected in England were obtained from the Chatsworth Conservatory, and probably were on imported wood. It is common in the extreme southern United States and cosmopolitan in the tropics. *H. truncatum* is the only annulate species in temperate North America, and it does not occur in the extreme northern part.

Léveillé's type, illustrated here, is exactly like the specimens obtained by Berkeley from Chatsworth. Ellis called the mature form *H. polyspermum* Mont. (see Ellis & Everhart, 2nd ser. N.A.F. no. 1788). The co-type of that species, however, at Kew is a *Camarops* and not a *Hypoxylon*. Many American mycologists, including the writer, have called it *H. effusum* Nits., following Saccardo in Myc. Ven. no. 1470, but Nitschke's type at Münster is *H. serpens*, and *H. stygium* probably does not occur in Europe.

*Material examined*

Herb. Kew. no. 785, under *Sphaeria marginata* Schw. Chatsworth, Herb. Berk.

Spec. in Paris Museum from St Dominique. Léveillé's type.

Fung. Cubensis Wrightiana no. 830. Herb. Kew. no. 726.

Petch no. 4832, Hakgala, 1916. Herb. Kew. under *H. marginatum.*

Petch no. 4465, Peradeniya 1914, under *H. punctatum.* Herb. Kew. no. 1366, co-type.

Mus. Bot. Berol., Africa, 1884. Herb. Kew. no. 1296, co-type of *H. annuliforme* Rehm.

Bot. Gard. Buitenz., Java, 1907. Herb. Kew. no. 1300, co-type of *H. bogoriense* von Höhnel.

Sacc. Myc. Ven. no. 1470, under *H. effusum* Nits. Herb. Kew. no. 1078.

Rav. Fung. Amer. no. 347 and no. 346, Darien, Ga., 1879. Cited by Saccardo under *H. microcarpum.* Herb. Kew. nos. 727–8.

Rav. F.N. Amer. no. 2460, Darien, Ga., under *H. marginatum.* Herb. Kew. no. 729.

## *The Genus* **Nummularia** Tul.

The generic name *Nummularia* Tul. (1863) is a later homonym of the valid generic name *Nummularia* Galib. (1781), a genus of Angiosperms, and should therefore be rejected under the Rules. In the list of *nomina conservanda* submitted to the International Botanical Congress at Cambridge by C. L. Shear, also in that of R. Maire, the name *Nummularia* Tul. was presented for conservation with *Nummularia Bulliardi* Tul. as the type species, because it was the first one described by Tulasne.

The separation of this genus from *Hypoxylon* Bull. ex Fr. has been based solely on Tulasne's figure in which a conidial layer is shown under a stroma. Lindau (3) says, "Conidienlager unter der obersten Schicht des Stromas gebildet, später frei.... 1. *Nummularia.*" This is contrasted with conidia free from the first in *Hypoxylon.* In species closely allied to *N. Bulliardi* I have found the conidia to be borne on the surface of the ectostroma in the same manner as in *Hypoxylon* (4).

*Nummularia Bulliardi* has no single character which separates it from the majority of species of *Hypoxylon.* It is convex and the perithecia are borne in the periphery of the stroma. Those who favour making this the type, maintain that the stroma does not tend to break up into separate perithecial stromata as is true of most effused species of *Hypoxylon.* This seems to be a thoroughly unworkable separation, because in the usual run of effused, applanate forms of *Hypoxylon* found in herbaria, there are many specimens that would be generically indeterminable. Use of this character has already led to much confusion. Ellis, for example, described *Nummularia lateritia* on an

effused specimen of *Hypoxylon rubiginosum*, which has no indication of perithecial elevations, although this species when erumpent through hard wood becomes semiglobose and is often seen composed of almost entirely separate perithecial stromata. Therefore, *Nummularia Bulliardi* and all allied forms should be put back into the genus *Hypoxylon*.

It is proposed to retain the genus *Nummularia* but to use the second species described by Tulasne, *N. discreta* (Schw.) Tul., as the type of the genus. In this species, the development of which has been described by me (4), by Gloyer (2) and others, there are characters which separate it from *Hypoxylon* on the one hand and *Anthostoma* on the other. The perithecia are not borne in the periphery of the stroma ((4), Pl. XXXVI, figs. 3–4), but are developed in the base, and reach the surface by more or less elongate ostiolar necks. This character is similar to *Anthostoma*, but *Nummularia* differs in being composed almost entirely of coalesced fungal hyphae, while in *Anthostoma* the structure is distinctly valsoid.

*Bolinia* Nits. ex Sacc. is a synonym, because the type species, *Sphaeria tubulina* A. & S. ex Fr., is based on a specimen distributed by Fries, a portion of which is in Nitschke's herbarium and another portion in Kew. The specimen consists of perithecia, more or less polystichous with long necks, sunk in a stroma. I have not seen Albertini and Schweinitz's specimens, but their figure (1) shows this character very plainly.

An emended diagnosis of the genus *Nummularia* to include the above characters is given below.

***Nummularia*** Tul. emend.

*Hypoxylon* pr. p. Fr. *Summa Veg. Scand.* (1849), pp. 383–4.
*Nummularia* Tul. *Sel. Fung. Carp.* II (1863), 42.
*Bolinia* Nits. subgenus under *Hypoxylon. Pyr. Germ.* (1867), p. 26.
*Bolinia* Sacc. *Syll. Fung.* I (1882), 352.
*Numulariola* House in *Rep. N.Y. State Museum*, 266 (1925), 49.
Type species: *Nummularia discreta* (Schw.) Tul.

Stromata discreta, orbicularia, saepe irregulariter effusa, marginata, applanata ad concava. Perithecia in basi entostromatos formata, ad superficiem plus minusve elongato ostioloso collo advenientia, monosticha ad polysticha. Asci cylindracei, 8-ascosporis, monostichis, ellipticis ad subglobosos, inaequilateralibus, maturitate atro-fuscis. Conidia continua hyalina, minuta, in superficie conidiophorum ectostroma tegentium formata.

1. ***Nummularia discreta*** (Schw.) Tul. *Sel. Carp.* II (1863), 45, tab. 5, figs. 1–10.

*Sphaeria discincola* Schw. *Syn. Car.* (1822), no. 63.
*S. discincola* Schw. ex Fr. *Syst. Myc.* II (1823), 368.
*S. discreta* Schw. *Syn. N. Amer. F.* (1832), no. 1249.

*Sphaeria excavata* Schw. *Syn. N. Amer. F.* (1832), no. 1250.
*Diatrype discincola* (Schw.) Curt. in *Geol. and Nat. Hist. Survey N.C.* III (1867), 141.
*D. discreta* (Schw.) Curt. *loc. cit.* (1867), p. 141.
*Hypoxylon discretum* (Schw.) Berk. in *Grev.* IV (1876), 94.
*Anthostoma discincolum* (Schw.) Sacc. *Syll. F.* I (1882), 296.
*Nummularia discincola* (Schw.) Cke. in *Grev.* XII (1883), 6.
*N. excavata* (Schw.) E. &. E. in *Journ. of Myc.* V (1889), 20.
*Numulariola discreta* (Schw.) House in *N.Y. St. Mus. Rep.* (1925), no. 266, p. 49.

Type: Specimen in Herb. Kew., no. 1438, under *Sphaeria discreta* L. v. S.

(Pl. VI, fig. 4)

Stroma developed below surface of wood or bark, becoming slightly erumpent at maturity by the breaking away of the surrounding matrix, discrete, marginate, concave, 3–5 mm. in diameter, light grey to almost black; entostroma slightly developed, mixed with wood, ectostroma swelling and throwing off covering bark; perithecia sunken in base of stroma drawn out into distinct necks, penetrating surface with minute, punctiform ostiola which are scarcely visible in old specimens; asci cylindrical, short-stalked, 160–200 × 12–15 $\mu$; ascospores semiglobose to globose, finally black, 12–14 $\mu$ in diameter. Conidia continuous, hyaline, borne on surface of ectostroma after the bark has been pushed off.

On *Pyrus*, *Amelanchier*, *Carya*, *Magnolia*, and reported on many other hosts. Very common in temperate North America as the cause of the blister canker, or nail-head canker, of apple trees, and not very frequent in Europe. The only specimen in the Kew Herbarium from England is on *Pyrus Malus*.

Its closest European relative is *N. repanda* (Fr.) Nits. and this species is distinct in having narrowly elliptical spores and protruding, widely perforated ostiola.

As a matter of priority the name *discreta* should be replaced by *discincola*. Schweinitz under the diagnosis of *Sphaeria discreta* says that he once mistakenly distributed this to friends as the very rare Carolinian *Sphaeria discincola*. On p. 197, *loc. cit.* under no. 1276, *Sphaeria discincola*, he says that he never found this very distinct species in Pennsylvania, and that he distributed all his Carolinian specimens to European botanists, so that now he has none. Further, he says it is entirely different from his *S. discreta*, which he once took for it. In the Kew Herbarium are several specimens from Schweinitz labelled by him *S. discincola*, and also several named *S. discreta*, which are identical—a fact which Cooke observed. Tulasne states in the description of *Nummularia discreta* that the American specimens received from Schweinitz under the name of *Sphaeria discincola* are the same.

From the above it seems logical to suppose that Schweinitz in 1831 thought some of the specimens he had communicated to European botanists, under the name of *S. discincola*, were that species, and some were another species which he then describes as *S. discreta*, and sends some more specimens under this name. The fact that all of these specimens are identical, together with the derivation of the name *discincola* (included in a disc), appears to be sufficient evidence that Schweinitz was mistaken in thinking *S. discincola* distinct from *S. discreta*, and therefore the name *Nummularia discincola* is correct for this species.

The arguments for not accepting this name are that *N. discreta* has been applied to this fungus since Tulasne's work, and as such is found in pathological literature dealing with the blister canker of the apple and it would seriously discommode students of plant pathology to make this change after so many years. The name *N. discreta* then should be conserved.

*Material examined*

Herb. Kew. no. 1430, Mulgrave Woods, 1910, on *Pyrus Malus*. First British record.

Herb. Kew. no. 1434, under *S. discreta* L. v. S. ex Herb. Schweinitz.

Herb. Kew. no. 1438, under *S. discreta* L. v. S. ex Herb. Schweinitz.

Rav. Fung. Carol. no. 57, on *Magnolia*. Herb. Kew. no. 1446. Also in Cornell Herb.

Ellis N. A. F. no. 489, on *Pyrus Malus*. Mass. 1880. Herb. Kew. no. 1448.

Herb. Kew. no. 1594, under *S. discincola* Schw. ex Herb. Berk.

Herb. Kew. no. 1596, under *S. discincola* L. v. S. This specimen was given to Berkeley by Klotzsch, who obtained it from Schweinitz.

The writer has numerous specimens of his own collecting on *Pyrus*, *Amelanchier* and *Carya*.

2. ***Nummularia lutea*** (A. & S. ex Fr.) Nits. *Pyr. Germ.* (1867), p. 59.

This species was described(5) under *Hypoxylon*, but it should be placed in this connection rather than in that genus as explained under the description.

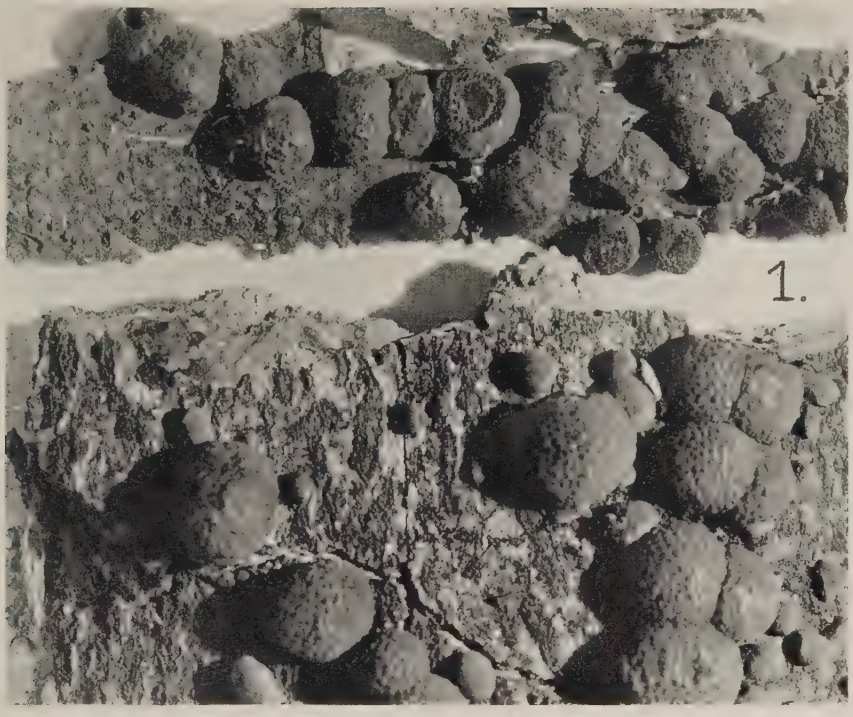
3. ***Nummularia gigas*** Plowr. in *Grev.* VIII (1879), 106, tab. 130, fig. 3.

While in England I saw no authentic specimen of this species nor did I collect it. Judging entirely from the illustration it may be a synonym of *Nummularia lutea*.

Other species which have affinities with *Nummularia discreta*, and so should be included in the genus, are as follows:

4. ***Nummularia tubulina*** (A. & S. ex Fr.) comb. nov.

*Sphaeria tubulina* A. & S. *Consp. Fung.* in *Agr. Nisk. cresc.* (1805), p. 6, t. 4, f. 4.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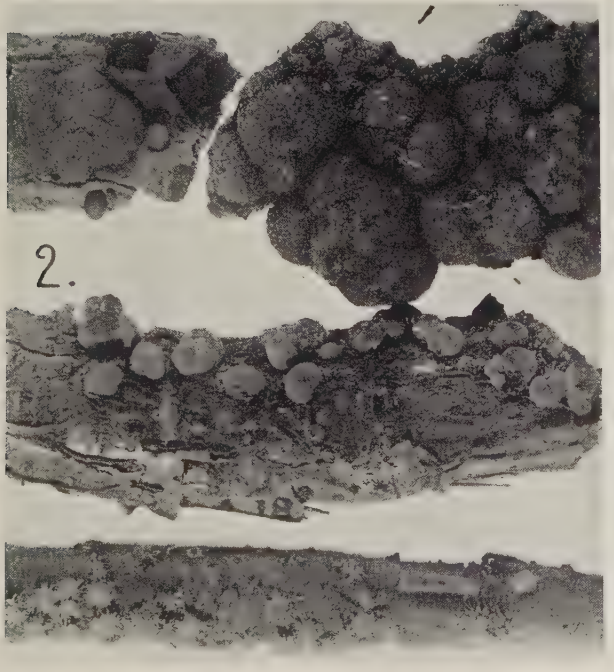
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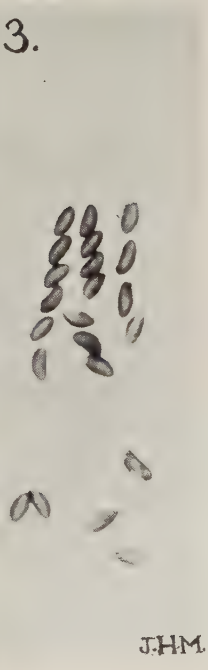
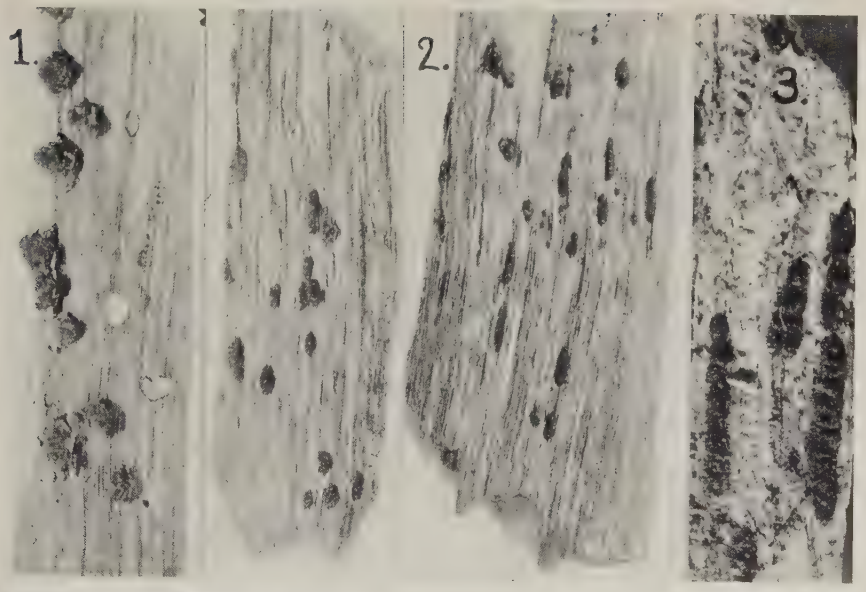

3.
J.H.M.


1.
2.
3.

4.
J.H.M.

*Sphaeria tubulina* A. & S. ex Fr. *Syst. Myc.* II (1823), 346.
*Hypoxylon tubulina* (A. & S.) Fr. *Summ. Veg. Scand.* (1849), p. 383.
*Bolinia tubulina* (A. & S.) Nits. subg. under *Hypoxylon, Pyr. Germ.* (1867), p. 26.
*B. tubulina* (A. & S.) Sacc. *Syll. F.* I (1882), 352.

No specimen reported from the British Isles, but found occasionally in Europe and North America.

5. ***Nummularia repanda*** (Fr.) Nits. *Pyr. Germ.* (1867), p. 57.
*Sphaeria repanda* Fr. *Syst. Myc.* II (1823), 346.
*Hypoxylon repandum* Fr. *Summ. Veg. Scand.* (1849), p. 383.
*Numulariola repanda* (Fr.) House in *Rep. N.Y. State Museum*, 266 (1925), 49.

Found in Europe, but not reported from England.

## EXPLANATION OF PLATES IV–VI

### Plate IV

Fig. 1. *Hypoxylon Howeianum.* × 10. The external characters are the same as those of *H. coccineum.*
Fig. 2. Showing different stages of development and also the coalescing due to crowding. The bottom photograph shows the parasitic growth long thought to be the conidial stage.
Fig. 3. Mature ascospores. Photomicrograph at same scale as spores in Text-fig. 1.

### Plate V

Fig. 1. *Hypoxylon udum.* Nat. size. Showing stroma not immersed.
Fig. 2. Showing stroma almost immersed.
Fig. 3. A portion of Fig. 2. × 20.
Fig. 4. *Hypoxylon nummularium.* × 10. Showing the minutely papillate ostiola. A. W. Bartlett collection.

### Plate VI

Fig. 1. *Hypoxylon stygium.* × 5. A portion of Léveillé's type from the Paris Museum.
Fig. 2. Part of above enlarged, × 25, showing annulate disc surrounding each ostiolum.
Fig. 3. Showing young stage in which the disc is beginning to grow through the ectostroma. At this period it is a shade of red or reddish slate colour.
Fig. 4. *Nummularia discreta.* × 10. Showing the concave stromata with very faintly visible sunken ostiola.

## REFERENCES

(1) Albertini, J. B. and Schweinitz, L. D. *Consp. Fung. in Agr. Nisk. cres.* (1805).
(2) Gloyer, W. O. "Blister canker of apples and its control." *N.Y. Agri. Exp. Sta. Bull.* no. 485 (1921). Geneva.
(3) Lindau, G. "Pyrenomycetineae." Engler und Prantl, *Die natürlichen Pflanzenfamilien*, I (1897), 1, 481.
(4) Miller, J. H. "Biologic studies in the Sphaeriales. II." *Mycologia*, XX (1928), 305–38.
(5) —— "British Xylariaceae." *Trans. Brit. Myc. Soc.* XV (1930), 134–54.
(6) Schweinitz, L. D. "Synopsis Fungorum Caroliniae superioris." *Schrift. Naturf. Ges. Leipzig*, I (1822), 34, no. 63.
(7) —— "Synopsis Fungorum in America boreali media degentium." *Trans. Amer. Phil. Soc.* II (1832), 4, 195–8.

# BRITISH XYLARIACEAE. III

## A REVISION OF SPECIMENS IN THE HERBARIUM OF THE ROYAL BOTANIC GARDENS, KEW

By JULIAN H. MILLER, Ph.D.

In my two previous papers I attempted to monograph the British species of the genera *Hypoxylon*, *Nummularia*, *Daldinia* and *Camarops*. Here the British species in the Kew Herbarium are listed according to my determinations, to serve as a supplement indicating possible localities for future collecting. The number in Clarendon type is one placed on the herbarium sheet by me, and not by the original collector. This was done because in most instances the specimens had no numbers. The name is the original one borne by the specimen. Notes on specimens in the herbaria of Nitschke and Persoon have been added.

***Hypoxylon coccineum*** Bull. ex Fr.

*Sphaeria fragiformis* Pers. 8: Bristol, no. 180. Herb. Berkeley. 71: Herb. Cooke. 120: Klotzsch, no. 19. In truncis Fagi, near Glasgow, very common. 189: Apethorpe, Northants. Herb. Berkeley.

*Sphaeria multiformis* Fr. 426: Herb. Cooke.

*Hypoxylon coccineum* Bull. 17: Kew Gardens, E. G. Baker, May, 1887, on *Fagus*. Det. Cooke. 18: Kew Gardens, E. G. Baker, Oct. 1884, on *Fagus*. Det. Cooke. 27: Carlisle, Dr Carlyle, Aug. 1885, on *Fagus*. Det. Cooke.

*Hypoxylon coccineum* Bull. 28: Kew Gardens, Oct. 1884, on *Fagus*. Det. Cooke. 99: Cke. no. 80, *S. fragiformis* Pers. Herb. Dawson Turner. 115: Burnham Beeches, 1890, on *Fagus*. Herb. Cooke. 192: Kew Gardens, 1884, on *Fagus*. Herb. Cooke. 194, 196: Kew Gardens, 1884, on *Fagus*. (Placed in *H. majusculum* cover by Cooke.) 195: Carlisle, Dr Carlyle, Aug. 1885. (Under *H. majusculum*.)

*Hypoxylon multiforme* Fr. var. 188: Cke. Fung. Brit. 1, no. 374, April, 1864. Southgate (cited by Cooke as the type of *H. majusculum* Cooke). 462: Cke. Fung. Brit. 1, no. 374, Southgate, 1870, on *Fagus*.

*Hypoxylon majusculum* Cke. 193: *Sphaeria fragiformis* Pers. var. *major*. Herb. Cooke.

*Herb. Persoon, 'Rijks Herbarium, Leiden*

910, 267–646. *Sphaeria fragiformis* Pers. Mougeot, on *Fagus*. Type.

*Herb. Nitschke, Münster, W.*

*Hypoxylon coccineum* Bull.—*Sphaeria fragiformis* Pers. on *Fagus*, C. Mougeot, 1864, on *Fagus*.

(Only two mature specimens in Nitschke's herbarium.)

The specific name *H. coccineum* is not correct according to the International Rules, and should be superseded by that of *Hypoxylon fragiforme* (Pers. ex Fr.) Kickx, unless the next Congress conserves it.

All the specimens of this species in the three herbaria studied are on *Fagus*.

### ***Hypoxylon Howeianum*** Peck

*Sphaeria fragiformis* Pers. 3: Northants, ex Herb. Berkeley. 7: Arddog, nr Barmouth, Mr Salway. Herb. Berkeley. 9: Bungay, Mr Stock. Herb. Berkeley. 23: Klotzsch, no. 19, from Greville. (Spec. on right.) 25: Rev. R. B. Francis, on *Quercus*. 45: no. 1, Newton. Herb. Berkeley.

*Lycoperdon acariforme* Sow. 50: Rudloe, April 7, 1843. Herb. Berkeley.

*Hypoxylon coccineum* Bull. 97: Dunmore, 1878. 102: Rev. Bloxam, Det. Cooke. 113: Plowr. Sphaer. Brit., Cent. 2, no. 12, 1875, Hereford. 175: Hereford, 1875. Det. Cooke. (Massee wrote "*H. commutatum* Nits." on this packet.)

*Herb. Persoon*

910, 267–643. *Sphaeria fragiformis* Pers. on *Quercus*. Leg. Junghuhn.

*Herb. Nitschke*

*Hypoxylon coccineum* Bull. on *Salix caprea*. Wolbeck, 10–'66.

(The part of Fuck. F. Rhen. no. 1056, on *Carpinus*, cited by Nitschke as the type of *Hypoxylon commutatum*, is here, but sterile.)

### ***Hypoxylon argillaceum*** Pers. ex Berk.

*Hypoxylon argillaceum* Fr. 128: C. B. Plowright, N. Wootton. Herb. Cooke. 130: Rabenhorst, Fungi Europaei, no. 247. Batheaston. C. E. Broome. 132: Herb. Cooke. 138: Plowright, Feb. 3, 1873. Herb. F. Currey. 139: Plowr. Brit. Ex. no. 19, 1873. 147: King's Cliffe. Herb. Berkeley.

*Sphaeria argillacea* Pers. 129: Herb. Cooke. 131: nr Bath, March, 1878. Herb. Cooke. 133: Keene Farm, nr Sandgate, Sept. 20, 1857, on *Fraxinus*. Herb. Cooke. 140: Apethorpe, Northants, on *Fraxinus*. Herb. Berkeley. 141: Weybridge, Sept. 10, 1856. 142: Saltwood, Sept. 17, 1857. 143: Eltham Grove, June 6, 1855. 145: Penzance, on *Fraxinus*. Herb. Berkeley. (Spec. on left.) 146: Ashton Wold. Herb. Berkeley.

*Sphaeria argillacea* Pers. 184: King's Cliffe. Herb. Berkeley. 150: Apethorpe, Northants. Herb. Berkeley.

*Herb. Persoon*

910, 270–516. *Sphaeria argillacea*, no. 58, on *Fraxinus*. Type. Ex Muhlenberg. 910, 18–199. no. 50. Amer. bor. on *Fraxinus*.

*Herb. Nitschke*

*Hypoxylon argillaceum* Cappenberg, on *Fraxinus*, 8–'64 (2 specimens).

The trivial name *argillaceum* is found generally throughout mycological literature applied according to Persoon's usage; it is, however, of doubtful validity. Fries, in *Systema Mycologicum*, p. 333, uses the name *Sphaeria argillacea* Fr., and the type of his species at Upsala is identical with *S. fragiformis* (*Hypoxylon coccineum*), and should be cited as a synonym under *S. multiformis* Fr. *Hypoxylon argillaceum* Pers. ex Berk. (1860) is, therefore, a more recent homonym of *Hypoxylon argillaceum* Fr. (1823). The former name, however, should be conserved considering its long employment in the sense that Persoon used it.

***Hypoxylon fuscum*** Pers. ex Fr.

*Sphaeria fragiformis* Pers. 86: April, 1842, ex herb. Greville. Herb. Cooke.

*Hypoxylon coccineum*. 92: Herb. Cooke. 93: Hereford no. 75. Herb. Cooke.

*Hypoxylon fuscum* Fr. 241: Glamis, Scotland, 1876. Herb. Berkeley. 242: Glamis, Scotland, 1874. Herb. Berkeley. 245: Glamis, Scotland, 1876. Herb. Berkeley. 256: Coll. Baxter. Herb. Oxon. 257: Cambridge, April, 1885, on *Corylus*. Herb. Cooke. 258: Herb. R. Heward, no. 47. Det. Cooke. 259, 260: Glamis, Scotland, March, 1874. Herb. Berkeley. 274: Cke. Fung. Brit. no. 246, Hampstead. 275: Shrewsbury. Herb. W. A. Leighton, 1858. Herb. Cooke. 276: Bungay, Mr Stock. Herb. Cooke. 277: Leatherhead, 1876. Herb. Cooke. 278: Hauxley, 1864, on *Corylus*. Herb. Cooke. 279: Leatherhead, 1876. Herb. Cooke. 280: Cke. Fung. Brit. no. 467, 1872. Highgate. 297: Herb. Cooke. 303: Plowr. Brit. Fung. Ex. no. 20, 1873. 307: Cke. Fung. Brit. Ex. no. 246, 1867. Hampstead. 310: Herb. W. A. Leighton, no. 16, Haughmond. 311: Cke. Fung. Brit. Ex. no. 467, 2nd ed. Highgate, 1872. 312: J. E. Vize, Micro-fungi Brit. no. 276. 329: Ardrossan, Ayr, Scotland, W. Boyd, 1887.

*Hypoxylon fuscum* Fr. 331: Herb. Dawson Turner. 336: Rev. A. Bloxam, on *Corylus*. 337: W. Shrewsbury, Almond Park, W. A. Leighton, 1850. 338: Twycross, Rev. A. Bloxam, 1850.

*Sphaeria fusca* Pers. 243: Warwickshire. Herb. Berkeley. 244: I. O. Leep. Herb. Berkeley. 246, 247: no. 50, May, 1875. Herb. Berkeley. 260: Glamis, Scotland, March, 1874. Herb. Berkeley. 261: Northants. Herb. Berkeley. 262: Westwater, Fifeshire, Gardiner, no. 49. Herb.

Berkeley. 263: Dolgelly, Merioneth. Herb. Berkeley. 264: Twycross, Leicestershire, Rev. Bloxam, on *Betula*. 265: F. Currey. Herb. Berkeley. 266: King's Cliffe, May, 1843. Herb. Berkeley. 267: Powerscourt, Sept. 1867. Herb. Berkeley. 268: Thirsk, Yorks, E. G. Baker. Herb. Berkeley. 285: Herb. W. Gardiner, Den of Airly, May, 1845. 286: Rev. J. L. Seepe, Audley End, Essex, Feb. 1873. Herb. Cooke. 302: Herb. Cooke. 304: Klotzsch, no. 20. 305: Klotzsch, no. 20. 306: ex Herb. Berkeley. 314: Grant, no. 75, Sussex, Com. E. G. Baker, 1887, on *Corylus*. 320: Northants, ex Herb. Berkeley. 321, 322, 323, 324: Klotzsch, ex Greville, no. 20. 326: Herb. Berkeley. 327*a*: Herb. F. Currey. S.J.S. 328: Bungay, Stock, on *Corylus*.

*Herb. Persoon*

910, 267–604. *Sphaeria fusca* var.

910, 267–502. *Sphaeria fusca* var. *junior*.

*Sphaeria fusca* Pers. 910. Type. 267–143, 267–675, 267–664, 267–139, 267–658, 267–671, 267–745.

*S. argillacea* Fr.? *Cohaerens junior*? Prope Parisior. 910, 270–341.

*S. atropurpurea* Fr.? *fusca* P. (written by Persoon). 910, 270–305.

*Herb. Nitschke*

*Hypoxylon fuscum* Fr. near Münster, 2/63, on *Corylus*. Münster, '64. Münster, on *Corylus*. no. 29, on *Corylus*, b. Münster, 2/63. Lutkenbeck. no. 39, on *Corylus*. no. 48, Wolbeck, 3/64. Schloss-garten, 10/64, on *Corylus*, 10/66. Nienberg. no. 29, on *Corylus*.

***Hypoxylon rubiginosum*** Pers. ex Fr.

*Hypoxylon cohaerens* Fr. 343: Cke. Fung. Brit. Ex. no. 666, 1872. 360: Penzance, no. 157. Herb. Berkeley.

*Sphaeria cohaerens* P. 361: no. 605. Herb. Berkeley.

*Hypoxylon multiforme* Fr. 420: Chingford, Essex, Nov. 1883. Herb. Cooke. 422: var. *effusum* Plowr. Cke. F. Brit. Ex. no. 668, 1872. 423: on *Fraxinus*, Herb. Cooke. (Also *Peniophora cinerea*.) 427: Leatherhead, Cooke, no. 7. 428: C. B. Plowright. 429, 430: Cke. Brit. Fung. Highgate, 1864.

*Hypoxylon rubiginosum* Fr.? 488: J. E. Vize, Micro-fungi Brit. no. 155, on *Fraxinus*. 535: var. *effusum* Cooke, Morpeth.

*Sphaeria multiformis* Fr. 438: Herb. W. A. Leighton, Wiltshire. 443: Haughmond Hill, W. A. Leighton, no. 237, Aug. 1850. 444: Klotzsch, on *Betula*. 450: var. Twycross, Herb. Berkeley. 453: Herb. Berkeley. 500: on *Fraxinus*, Herb. Berkeley. 504: H. O. S. Bristol. 505: var. on *Fraxinus*, May 12, 1859. Herb. Berkeley. 507: Penzance, no. 29. Herb. Berkeley. 508: Oswestry. Herb. Berkeley. 511: var. Herb. Berkeley. 536: *β. granulosa*, Klotzsch, no. 23*b*. 538: Milton, Mr Henderson. Herb. Berkeley. 545: var. Herb. Berkeley.

*Sphaeria multicapsula* Fr. 499: t. 436, no. 2, Mr Newton, Nov. 2, 1810. Herb. Berkeley.

*Hypoxylon perforatum.* 869: Kew Gardens on Indian Corn. Herb. Cooke.

*Sphaeria atropurpurea* Tode. 876: Herb. Cooke.

*Hypoxylon atropurpurea* Tode. 877: Bishop's Woods, Dec. 1865. Herb. Cooke. 878, 879: Herb. Cooke.

*Sphaeria rubiginosa* Pers. 891, 894, 895, 896: Klotzsch, no. 37. 892: King's Cliffe, ex Herb. Berkeley. 893: Klotzsch, no. 340. 903: Saltwood, Sept. 1857. Herb. Currey. 928, 930: Northants. Herb. Berkeley. 929: Penzance, no. 159. Herb. Berkeley. 932, 933, 934: Northants. Herb. Berkeley, Nov. 1855. 935: Northants. Herb. Berkeley, Nov. 2, 1847.

*Hypoxylon rubiginosum* Fr. 902: near Ringmer, Sussex. Sept. 1863, F. Currey. 904: De Thüm, Myc. Univ. no. 1071, on *Fraxinus*, ex Plowright, 1878. 905, 906: Saltwood, Sept. 1857. Herb. Currey. 907: Plowr. Brit. Fung. Ex. no. 21. 912: Vize, Micro-fungi Britannici, no. 493.

*Sphaeria corrugata* Fr. 1310: Penzance no. 169, Herb. Berkeley.

*Herb. Persoon*

910, 263–1194. *Sphaeria rubiginosa* Pers. Vandul. Det. Léveillé.
910, 263–1191. *Sphaeria rubiginosa* Pers. Prope Parisior. Type.
910, 270–281. *Sphaeria atropurpurea* Fr. (Very old.)
910, 267–365. *Sphaeria granulosa* var.? Mougeot.
910, 267–362. *Sphaeria granulosa* Pers. On *Salix*. Chaillet. Type.
910, 267–141. *Sphaeria fusca.* Mougeot, no. 19.
910, 269–452. *Sphaeria rubricosa*?

*Herb. Nitschke*

*Hypoxylon purpureum* Nits. Wolbeck, 3–'64. Type. 4–'65, 4–'65. Nienberg, 2–'66. (2 specimens.)

*Hypoxylon rubiginosum* Pers. 6–'64, 6–'64. On *Fagus*, 9–'65, 10–'66. On *Cerasus*, 8–'66. Cappenberg. On *Acer campestris*, 10–'66. Nienberg.

*Sphaeria rubiginosa* Pers. *Hypoxylon*, 1834.

*Hypoxylon fragile* Nits. n.sp. Gasselstiege, 5–'64. Type. 6–'66.

*Hypoxylon perforatum.* On *Salix fragilis*, 10–'66. Nienberg. On *Fraxinus*. Cappenberg, 8–'66. Wolbeck, 4–'65. b. Erdmanns, 8–'66.

*Hypoxylon luridum* n.sp. On *Corylus*, 8–'64. Type. Wilkinghege.

*Hypoxylon Botrys* Nits. On *Quercus*, 10–'65. Type. Nienberg.

*Hypoxylon Laschii* n.sp. Type.

The list of determinations by English mycologists shows that the *H. multiforme* var. *effusum* of British literature is *H. rubiginosum.* The effused reddish form of *H. multiforme* has the papillate ostiolar character of the species, which should readily separate it from *H. rubiginosum.*

To the list of synonyms under *H. rubiginosum* ("Brit. Xylariaceae, I," p. 144) the writer desires to add *H. fragile* Nits., *H. Botrys* Nits., and *H. Laschii* Nits. The types of these species in the Münster Herbarium are typical forms of *H. rubiginosum* such as one finds on *Fraxinus* in England.

***Hypoxylon rutilum*** Tul.

870. *Hypoxylon miniatum* Cke. Shere, April, 1870. Type.

*Herb. Nitschke*

*Hypoxylon rutilum* Tul. On *Fagus*, 10–'65. Cappenberg, 8–'66. Wolbeck, 10–'66. Gasselstiege, 10–'66. Wolbeck, 8–'65.

The Kew Herbarium contains an authentic specimen from the Paris Herbarium which is identical with the specimens cited above. *H. rutilum* appears to be confined to *Fagus*, and is more commonly effused than pulvinate.

***Hypoxylon cohaerens*** Pers. ex Fr.

*Hypoxylon cohaerens* Fr. 344: Fairmead, Epping, S. 1888.

*Sphaeria cohaerens* Pers. 378: Herb. Dawson Turner, no. 57, on *Fagus*.

*Sphaeria granulosa* Sow. 552.

*Herb. Persoon*

910, 270–69. *Sphaeria cohaerens* Pers.

910, 270–57. *Sphaeria cohaerens* Pers. *junior*, from Mougeot.

910, 270–61. *Sphaeria cohaerens* Pers. *affinis*.

910, 270–92. *Sphaeria cohaerens* Pers. Syn. Meth. Fung, p. 11. Type.

910, 270–70. *Sphaeria cohaerens* Pers. Mougeot.

*Herb. Nitschke*

(Many specimens, not numbered. All on *Fagus*.)

Judging from the few specimens in the Kew Herbarium, *H. cohaerens* is very rare in England; it is quite common on the continent and in Northern North America.

***Hypoxylon multiforme*** Fr.

*Hypoxylon coccineum* Bull. 35: Klotzsch, no. 146, 1884.

*Sphaeria multiformis* Fr. 190: Herb. Cooke, no. 9 (under *H. majusculum* Cke.). 191: Colney Hatch, April, 1864. Herb. Cke. (under *H. majusculum* Cke.). 424: Hoffm. Herb. Cooke. 439: Herb. W. A. Leighton, Feb. 1850. 440: Herb. Dawson Turner. *S. granulosa* Sow. Herb. Cooke. 442: Rev. T. Salway. Herb. W. A. Leighton, on *Betula*. 445, 446, 447, 448: Klotzsch, *S. elliptica* ex Greville. 451: Penzance, no. 153. 455: Apethorpe, Northants. Herb. Berkeley.

456: Wraxall, C. E. Broome, 1865. Herb. Berkeley. 460: Bristol, Berk. Brit. Fung. no. 170, 1836–43. 502: Herb. Berkeley. 506: Milton. Herb. Berkeley. 529: Klotzsch, no. 23. Herb. Berkeley. Woods by Loch Lomond. 530: Milton, Northants. Herb. Berkeley. 533, 534: *S. rubiformis* Pers. Klotzsch, no. 23. 536: *β. granulosa* Klotzsch, no. 23. 539, 543, 544, 546, 547: Klotzsch, no. 23. 541: Apethorpe, Northants. Herb. Berkeley. 551: Herb. Berkeley.

*Hypoxylon multiforme* Fr. 441: Rev. A. Bloxam, Bristol. 449: Plowr. Brit. Ex. no. 18, 1873. 521: Com. E. G. Baker, 1887. Det. Cooke. 522: Com. E. G. Baker. Frant, Sussex, on *Betula*, April 14, 1875. Herb. Cooke. 523: Com. E. G. Baker, Highrocks, Sussex, on *Betula*, April, 1875. Herb. Cooke. 526: Com. E. G. Baker, 1887. Herb. Cooke. 549: De Thüm. Myc. Univ. no. 2174, ex Plowright, 1883. 558: Com. E. G. Baker, May, 1889, Sussex. 559: Worcester, C. Rea, no. 5.

*Sphaeria granulosa* Sow. 516: Herb. Berkeley. 517: Belvoir, 1854. Herb. Berkeley. 531: Klotzsch, no. 23, ex Greville.

*Herb. Persoon*

910, 270–277. *Sphaeria atropurpurea* Fr.
910, 270–338. *Sphaeria atropurpurea* Fr. *S. granulosa*? Pers. Gallia.
910, 269–426. *Sphaeria rubiformis* Pers. Kunze under *S. cohaerens*.
910, 269–438. Chaillet.
910, 269–437. *S. rubiformis* Pers. on *Betula*. Type.

*Herb. Nitschke*

*Hypoxylon durissimum* (Schw.) Fr. no. 100. (Four packets. All young.)

*Hypoxylon multiforme* Fr. (Several packets. All on *Betula*.)

*Hypoxylon crustaceum* (Sow.) Nits. (Effused form of *H. multiforme*.)

*Hypoxylon atropurpureum* Fr. (Effused form.)

The specimens of *Sphaeria atropurpurea* from Fries, in the Kew Herbarium, as well as those in the Persoon and Nitschke Herbaria, are *Hypoxylon multiforme* in the effused state, such as one sees on decorticated *Betula*. *H. durissimum* of Nitschke is a young, red form of *H. multiforme* and not *H. rubiginosum* as is the type of Schweinitz.

***Hypoxylon serpens*** Pers. ex Fr.

*Sphaeria cohaerens* Pers. 362: Penzance no. 129. Herb. Berkeley.

*Sphaeria multiformis* Fr. 501: Herb. W. A. Leighton, Oct. 1858. Herb. Berkeley.

*Sphaeria serpens* Pers. 1026: Herb. Cooke, no. 2027. 1025, 1027, 1031, 1032, 1033: Herb. Cooke. 1035: King's Cliffe, ex Herb. Berkeley. 1039: Klotzsch, no. 40. 1060, 1061: on *Quercus*, 1849. Herb. Berkeley. 1062: King's Cliffe, 1841. Herb. Berkeley. 1063, 1065: Northants. Herb. Berkeley.

*Hypoxylon serpens* Fr. 1034: Cke. Fung. Brit. no. 667, 1874. 1037: Llanforda near Oswestry, Shropshire. W. A. Leighton, Oct. 1838. 1038: Cke. Fung. Brit. Ex. no. 667, 1874. 1043: Vize, Micro-fungi Brit. no. 492. 1046: Plowr. Sph. Brit. Cent. 2, no. 10, 1875. 1047, 1048: Herb. Currey, from Plowright, 1873.

*Sphaeria deusta* Hoffm. 1116: Herb. Cooke. 1120: Klotzsch, ex Greville.

*Hypoxylon udum* Fr. 1213: Plowr. Sph. Brit. Cent. 2, no. 77, 1875.

*Hypoxylon semiimmersum* Nits. 1260: Baslow, May, 1915, A.D.C.

*Herb. Persoon*

910, 269–887. *Sphaeria serpens* Pers. Type.
910, 269–713. *Sphaeria serpens* var.
910, 269–763. *Sphaeria serpens*.
910, 269–892. *Sphaeria uda* Pers. Type.

*Herb. Nitschke*

*Hypoxylon effusum* Nits. no. 15. Type.

*Hypoxylon colliculosum* (Schw.) Nits. (A small piece of the specimen from Surinam collected by Schweinitz.)

*Hypoxylon aeneum* Nits. C. Erdmanns, August, '65. Type.

In the description of *H. serpens* (*Trans. Brit. Myc. Soc.* x, 142), I stated that this conception of the species is different from that of Fries as shown by his specimen at Upsala. This is a mistake, as Nannfeldt agreed in a letter to me after examining more English and American material. Owing to an oversight the error was not corrected. The several specimens of *Fr. Scler. Suec.* no. 47 in Kew Herbarium are identical with Persoon's type specimen of *Sphaeria serpens*.

The names *Sphaeria uda* Pers. and *Hypoxylon aeneum* Nits. should be added to the list of synonyms of *H. serpens*. Nitschke's type specimen of *H. aeneum* does not possess the large spores described in the diagnosis in *Pyr. Germ.* p. 47, but they fall within the range of measurements of *H. serpens*. The colour and characters of the ostiola are also typical of that species.

### ***Hypoxylon ustulatum*** Bull. ex Fr.

*Sphaeria deusta* Hoffm. Apethorpe. Herb. Berkeley. Klotzsch, no. 35. Herb. Berkeley. Apethorpe, Northants. Herb. Berkeley.

*Ustulina vulgaris* Tul. J. E. Vize, Micro-fungi Brit. no. 156. Cke. Fung. Brit. Ex. no. 465, 1872. Plowr. Sph. Brit. Ex. no. 15, 1873.

*Herb. Persoon*

910, 270–576. *Sphaeria deusta* Hoffm. no. 204.
910, 270–575. *Sphaeria deusta* Hoffm. Léveillé, no. 244.
910, 270–585. *Sphaeria deusta* Hoffm. no. 324.

910, 270–587. *Sphaeria deusta* Hoffm. Mougeot.
910, 270–584. *Sphaeria deusta* Hoffm. Muhlb. no. 245.
910, 270–578. *Sphaeria deusta* Hoffm.
910, 270–596. *Sphaeria deusta* Hoffm.

*Herb. Nitschke*

*Ustulina vulgaris* Tul. (Many specimens under this name.)

***Hypoxylon udum*** Fr. (non Pers.)

*Hypoxylon udum* Fr. 1196, 1197: Herb. Cooke. 1203: Herb. Berkeley.

*Sphaeria uda* Pers. 1205, 1206, 1207: King's Cliffe. Herb. Berkeley. 1208, 1209: Wothorpe, Sept. 1857. Herb. Berkeley. 1219: Sandling Park, Sept. 1857, F. Currey. 1226, 1228: Weybridge, Oct. 1857, F. Currey.

*Hypoxylon confluens*. 1276, 1277: Colwyn Bay, Oct. 1880. Herb. Cooke.

*Herb. Persoon*

*Hypoxylon udum* Fr. is not represented.

*Herb. Nitschke*

*Hypoxylon udum* Fr. (Three specimens on *Castanea*.)

***Hypoxylon semiimmersum*** Nits.

*Hypoxylon udum* Fr. 1198: Swanscombe Woods, April, 1866. Herb. Cooke. 1202: Herb. Cooke.

*Sphaeria uda* Pers. 1218: *S. confluens* Tode, on *Quercus*, Bentham Hill, Oct. 1856, F. Currey. 1220: *S. confluens* Tode, Hossock's Gate, Oct. 1854, F. Currey. 1222, 1223, 1224: Weybridge, April 7, 1856, on *Quercus*. Herb. Currey. 1227: Maxwell's Field, Kidbrook, March, 1858. 1229: Weybridge, March, 1858. Herb. Currey. 1230: Weybridge, March, 1857. Herb. Currey.

*Sphaeria confluens* Tode. 1239: Plowr. Sph. Brit. Cent. 2, no. 55, 1875, on *Salix*. 1242: North Bristol, Jan. 7. Herb. W. A. Leighton. 1248: Bristol, Oct. 1865. Herb. Berkeley. 1250: Rev. T. Salway, no. 7, Guernsey, on *Fraxinus*. Herb. Berkeley. 1262: Wraxall, C. E. Broome, Jan. 1865. Herb. Berkeley. 1263: Weybridge, Currey, no. 4, Sept. 1856. Herb. Berkeley. 1264: Powerscourt, Sept. 1867. Herb. Berkeley. 1265: Tansor, on *Salix*. Herb. Berkeley. 1266: Somerset, C. E. Broome. Herb. Berkeley. 1267: Wothorpe, Sept. 1857. Herb. Berkeley. 1268, 1269: Herb. Berkeley. 1273: Bristol, C. E. Broome, 1853. Herb. Cooke.

*Hypoxylon confluens* Berk. 1270: (= *semiimmersum*). Herb. Cooke. 1272: Coedloch, Wales, Oct. 1880. Herb. Cooke. 1274: Herb. Cooke.

*Herb. Persoon*

910, 270–377. *Sphaeria confluens* Tode?

910, 270–63. *Sphaeria confluens* Tode? From Desmazières. (Pers wrote "*S. albicans* P" on it.)

910, 270–62. *Sphaeria albicans*. Type.

910, 270–64. *Sphaeria albicans*. Type.

910, 270–141. *Sphaeria*? Mougeot. P. Verrucaria? by Moug. (Pers. wrote under it—*S. albicans*?)

910, 270–673. *Sphaeria albicans—Valsa affinis—Sphaeria mammaeformis*. Prope Parisior.

910, 269–886. *Sphaeria serpens*.

910, 269–820. *Sphaeria uda*? On *Quercus*, Mougeot. (Persoon wrote "*S. serpens*" on it.)

910, 269–903. *Sphaeria uda* var. *Salicaria*. Desmazières. Type of var.

*Herb. Nitschke*

*Hypoxylon semiimmersum* Nits. Wolbeck, no. 34. Type. *H. semiimmersum* Nits. On *Fagus*, 10–'66.

The name *Hypoxylon semiimmersum* probably should be supplanted by *H. confluens*. It is now impossible to determine accurately what Tode had in mind for *Sphaeria confluens*, because he left no specimen. Fries, however, in *Syst. Myc.* p. 342, under *Sphaeria confluens* cites Tode, but he also cites as synonyms *S. uda* var. *Salicaria* Pers. and *S. albicans* var. Pers. Types of the last two are identical with Nitschke's type of *H. semiimmersum*. The single specimen in the Fries collection at Upsala belongs to this species according to Nannfeldt, so there is no question about what Fries understood to be *Sphaeria confluens*.

In British mycological literature, Berkeley, Plowright and Cooke consistently used the name *H. confluens*, and only Currey confused this species with *H. udum* Fr. Cooke, on his specimens follows Berkeley and names them *H. confluens*, but in his *Syn. Pyr.* p. 16, he uses Nitschke's name. Then in *Hypoxylon and its Allies* (p. 140), he says "We find that the Rev. M. J. Berkeley regarded *H. confluens* as the species now answering to the name of *H. semiimmersum*, and we doubt not, as far as British Botanists are concerned, we should have their sympathy in restoring the name of *H. confluens* instead of *H. semi-immersum*."

The name *H. confluens* has not been applied in modern times because Nitschke, *loc. cit.* p. 54, cited it as a synonym under *H. minutum* Nits. This was a mistake, as Nitschke's type specimen of *H. minutum* consists of very few, entirely separate perithecia, having the appearance of *Rosellinia subiculata* (Schw.) Sacc., and also spores of that species.

***Hypoxylon stygium*** (Lév.) Sacc.

*Sphaeria marginata* Schw. 737: Chatsworth. Herb. Berkeley. 747, 748: Chatsworth, Miss Berkeley. 785: Chatsworth, W. R. Scott.

***Nummularia lutea*** (Alb. & Schwein. ex Fr.) Nits.

*Hypoxylon luteum* Fr. 1479: Batheaston, April, 1867. Herb. Berkeley. 1481: C. E. Broome, April, 1867. Herb. Berkeley. 1483: St Catharines, C. E. Broome, April 9, 1867. 1485: Cke. Sel. Fung. Ex. King's Lynne. On *Corylus*. 1487, 1488: King's Lynn, C. B. Plowr. Cke. Sel. Fung. Ex. 1490: King's Lynn, C. B. Plowr., on *Corylus*. Herb. Cooke. 1494: Plowr. Brit. Ex. no. 16, 1873. 1495: C. B. Plowright, Feb. 1872, Castle Rising. Herb. Cooke. 1496: C. B. Plowright. Herb. Cooke.

*Sphaeria lutea* A. & S. 1480, 1482: Clifton, Northants. Herb. Berkeley. 1484: Rev. A. B. Bloxam, Gopsal, no. 513. Herb. Berkeley. 1491: Herb. Berkeley. 1492: Berkeley, no. 113. 1493: Herb. Cooke.

*Nummularia lutea* Nits. 1486, 1489: N. Norfolk. Herb. Cooke.

*Sphaeria melanotes* B. & R. & *Diatrype lutea* A. & S. 1497: Currey, no. 76.

*Diatrype lutea* A. & S. 1498.

*Nummularia lutea* Nits. G. N. Nov. 1902. On dead boxwood. Kew Gardens.

*Herb. Nitschke*

There is no specimen in this herbarium, only a description in the cover marked *Nummularia lutea* (A. & S.) Nits.

In July, 1930, in company with Mr E. W. Mason I found this species in great quantity on stumps and dead branches of *Buxus sempervirens* on Box Hill.

***Nummularia discreta*** (Schw.) Tul.

1430. *Nummularia discreta* (Schw.) Mulgrave Woods, 1910, on *Pyrus Malus*.

*Herb. Nitschke*

*Nummularia discreta* (Schw.) Tul. no. 139.

# MEASURING GERMINATION

By R. G. TOMKINS

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There are several unsuspected difficulties in measuring germination, and failure to recognise them makes many of the toxicity curves, and the graphs of temperature relations which appear regularly in scientific journals, of very questionable value.

The chief source of error is, I think, that the criterion usually employed is the percentage number of spores which have germinated after some arbitrary time. There are other sources of error among which is a failure to distinguish between retardation, *i.e.* a delay in the appearance of the germ tubes or a decrease in the rate of elongation of the germ tubes, inhibition, *i.e.* the spores fail to germinate but are in no ways damaged, and killing, and also the frequency with which water rather than a nutrient liquid is used for the germination test.

It may be said that, in general, the measurement of germination recorded is a single figure expressing either the percentage number of spores germinating or the average length of the germ tubes after a definite time interval. Sometimes one, sometimes another of these is used, rarely both. I venture to think that many ambiguities might be avoided if three criteria were employed: (1) the latent period of germination, *i.e.* the average time for germ tubes to appear; (2) the percentage germination (not after so many hours but the final percentage number of spores germinating); (3) the rate of elongation of the germ tubes. It is, I think, always necessary to consider all three, though according to the spores used and the conditions of germination it may be advantageous to stress one or other in order to describe the course of germination most adequately.

Germination tests are mainly of two types. One is to find the effect of some previous environmental condition on the germination of spores, or to compare the germination of the spores of different fungi. For this, spore samples which have undergone different treatment or have been collected from different sources are germinated under similar uniform conditions.

In the second type of germination test, comparable samples of spores are germinated under conditions which differ in respect to one variable only, *e.g.* temperature, humidity, concentration of inhibitor, in order to find the effect of the variable on germination.

In the first type of test the percentage number of spores which germinate and the latent period of germination is of most interest. In the second it is chiefly the latent period and the rate of elongation which is affected rather than the percentage number germinating.

The percentage number of spores that germinate in any given sample is largely determined by the nutrient condition. Some spores do not germinate in water, some do so freely, others behave irregularly. Why there is this variation in behaviour in water has so far not been explained, but it seems evident that the line dividing germination and non-germination must be a narrow one. For this reason, nutrient solutions should be used for germination tests, wherever possible, rather than water.

Especially when testing the effect of some external factor is it advisable to assure that a maximum number of spores germinate by placing them on a nutrient surface. Under such conditions not only do greater numbers germinate but germination is more rapid and more uniform. Whether the nutrient surface on which to germinate spores is best obtained by using hanging drop cultures, agar plates or glass slides enclosed in air-tight jars will depend on the conditions it is wished to maintain.

The "latent period" of germination may be defined as the average time taken for spores to produce germ tubes. In no set of constant conditions will all spores put out germ tubes at the same moment, but the variation in time is not so great as to prevent an approximate value being set down as the time at which most of the spores have just begun to produce germ tubes. In order to find the latent period frequent observations are necessary, and this is one of the reasons in its favour.

The average length of the germ tubes gives perhaps the simplest method of measuring germination. If done at regular time intervals this also provides a list of figures which are easily plotted, and the graph so obtained often provides a clear picture of the course of germination.

The desirability of always using these several criteria is obvious when the way in which certain external factors affect the latent period of germination and the rate of elongation of the germ tubes, is considered. Though most factors can be varied to affect the rate of elongation of the germ tubes, the effect of these factors on the latent period varies considerably. In the presence of narcotics (ether, chloroform, acetone, etc.), certain acids, and such gases as sulphur dioxide, the latent period of germination is only slightly prolonged. It is noticeably prolonged by decreases in temperature and in humidity, and still more so by the presence of such substances as acetaldehyde, hydrogen cyanide, hydrogen sulphide. It is also prolonged by the presence of ammonia and the salts of heavy metals.

When there is marked interference with the latent period, errors in comparing the extent of germination can most easily arise. For example, if the effect of two substances on germination has to be compared and these affect the latent period in different ways, it is ex-

ceedingly difficult to make any simple quantitative estimate of their relative effects. A measurement of germination taken at any one time will be a rough integration of the effect on the latent period and subsequent elongation. Yet toxicity values based on arbitrary times of germination frequently appear.

For substances affecting germination in the same way a single figure may be of some value. For comparing the relative toxicity of substances with different types of action I think figures based on a single observation must be in most instances valueless and in every instance confusing.

Thus, though it would doubtless be simpler and more direct if the extent of germination could in any instance be expressed by some one figure, I suggest that it is not possible, and that it is only by recording the percentage number of spores germinating, the latent period of germination and the rate of elongation, that the course of germination can be fully described. Moreover it is by observation of the effect of external factors on the latent period that some idea of processes underlying germination are likely to be discovered.

# MEASURING GROWTH

## THE PETRI DISH METHOD

By R. G. TOMKINS

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One very generally adopted method of measuring the growth of fungi is to sow spores on nutrient agar contained on a Petri dish and to measure the diameter of the colony a few days later. The diameter of the colony is then used as a measure of the rate of growth.

For finding approximately the effect of such factors as temperature on the rate of growth this method is quite adequate, but it is by no means the most accurate measure of growth which may be obtained of a colony growing in a Petri dish. Moreover, its use would undoubtedly often give a wholly false idea of the actual rate of growth.

For these reasons I wish to bring forward a number of arguments for suggesting that in measuring growth on a Petri dish it is desirable to measure the diameter every twelve hours or so, to find the rate of increase in diameter and to use the rate of linear spread rather than mere size after so many days.

If the colony is measured from time to time and size is then plotted against time a characteristic curve is obtained. In the early stages the growth is not constant. Lateral spread does not begin immediately, for spores do not put out germ tubes at once. When growth begins it does so slowly, but the rate rapidly increases to a constant value. The curve of size, at first curving upwards, becomes linear. The stage of constant growth is rarely reached till the colony is some 3–4 cm. in diameter, but after this the rate of lateral spread remains constant. Sometimes there may be a later falling off of the growth rate. These facts are well known. Brown (1) has written: "The general feature of these curves (of the rate of growth, as measured in terms of the diameter of the colony) is that in the early stages the rate of growth is small, and that it then rises to a maximum which may or may not be maintained. Fungi which keep up this limiting rate of growth are described as being of the non-staling type; those in which the rate of growth falls off from the maximum are described as being of the staling type." Here and in subsequent papers, Brown was describing the facts of staling and laid stress on the falling from the maximum rate of spread. Because of his work, the phenomenon of staling is well recognised, much more so than that of constant growth. Consequently it may be said that staling rather than constant growth is believed in general to be the rule. For my own part I do not con-

sider this to be so, for I have found staling to be the exception and constant linear growth the general rule.

Now if there is in the growth of a colony on nutrient agar a phase of constant spread it seems that this most probably gives a better measure of growth under these conditions than the total growth after some arbitrary number of hours. Measuring growth on a Petri dish is analogous to measuring other physiological processes, and the rates of the processes, especially if steady states are attained, are of greater value than the sum total of change over long periods of time.

The practical advantage of a constant phase which can be used as a measure of growth is only one aspect of the value of this method. A continuous record of the rate of spread draws attention to the various phases of growth, to the initial phase of growth, to the phase of continuous growth, to the staling process if staling occurs, and forces interest in the mechanism of spread in culture. At the moment it is not clear what is the true relation between increase in diameter and growth. Cell division is taking place at the tips, and growth at the margin may be considered due to the addition of new units. The rate of spread is, therefore, possibly a measure of the rate of addition of new units and this must be approximately a measurement of cell divisions. Analysis in terms of cell division and the production of new organisms, has been employed in bacterial work, and it is of interest to note that there is a very close resemblance between the change in the average generation time of bacteria growing in a colony and in the change of time needed to add each successive unit increment to the diameter of a colony. If increase in diameter were found to be correlated with cell division its use as a measure of growth would be justified. It must, however, be emphasised that at present it is impossible to say how good a measure of growth is the diameter of the colony. But for ordinary growth studies the method of continuous measurement seems necessary if the changes of growth are to be properly evaluated.

Size after so many hours, which gives an approximate method of measuring growth at various temperatures, is sufficiently accurate for demonstrating the effect on growth of some other external factors. In the presence of such growth inhibitors as carbon dioxide or narcotics (chloroform, ether, alcohol, etc.), the rate of spread, though reduced, suffers no marked change of phase sequence, and comparison of size at various time intervals would give much the same relative values. It must, however, be recognised that it is possible to make this generalisation on the value of size as an index of growth, only after continuous measurements of the rate of spread have been made.

Often the reduction in growth brought about by some external factor is not simple and the different phases of growth are affected

differently. Here the use of size alone cannot be used even as an approximate measure of growth.

When growth takes place in the presence of certain substances the curve obtained by plotting diameter against time is very different in form from a similar curve representing growth in air. This is especially so when growth is in the presence of acetaldehyde, of hydrogen sulphide and of hydrogen cyanide. In the presence of these substances, germination and the lag phase are very noticeably prolonged. Their retarding effect therefore, is considerable in the early stages of growth. Later the growth in concentrations which markedly affect the lag phase increases to rates more nearly approaching those in air. A colony growing in air thus gains at first very considerably over those growing in the presence of aldehyde, etc., and when size is used as an index of growth it not only gives an inaccurate measure of growth but also fails to give any idea of the very interesting way in which the growth is actually retarded.

There are other cases when it is necessary to take continuous readings. One is in measuring the effect of some factor which cannot immediately be brought into a steady state. The rate of growth will change while conditions approach a true equilibrium. By continuous recording, the course of change can be followed and the final value of the rate of spread can be found. The total growth after any number of hours is here useless. I wish to give examples of two different types of changes towards equilibria which may be met with. One type involves physical conditions only, the other involves possibly the growing system itself.

Let us suppose we wish to measure growth in the presence of ammonia or of sulphur dioxide. If a method which I have described elsewhere (2) is used, the time required for the gas to dissolve in the agar and come into equilibrium with the pressure of gas in the air is considerable, especially when compared with the time taken for equilibrium to be established in other instances—for example when small quantities of chloroform, alcohol, etc., are introduced into the atmosphere. But by following continuously the rate of growth the final equilibrium can be obtained. Another such example is met with in measuring the effect of the external humidity when growth is on a medium of high water content, *e.g.* an ordinary culture medium. In these conditions water is continuously being lost by the medium. Continuous measurement of size and of water content is necessary to determine how water supply is influencing growth.

The other and quite different type of changing growth rate is met with when growing colonies are taken from air and placed in an atmosphere containing certain substances. The spread of the colony is immediately checked or considerably reduced. Later the growth again begins or increases in rate and finally attains a constant value.

At least three substances produce this effect—acetaldehyde, hydrogen cyanide and hydrogen sulphide, and the changes they bring about can be followed only by continuous observation.

So for a greater appreciation of the various phases of growth, for measuring growth when it has reached a final constant value, for knowing whether or not staling is affecting the extent of growth, for finding how certain factors affect differentially the various phases of growth, for noting how quickly or slowly equilibrium conditions are established and for a clearer picture of the mechanism of marginal spread I consider the method of measuring growth by following the rate of lateral spread not only worth while but almost essential if the Petri dish method is to be used at all.

REFERENCES

(1) Brown, W. "Experiments on the growth of fungi on culture media." *Ann. Bot.* xxxvii (1923), 105.
(2) Tomkins, R. G. *Food Investigation Board, Ann. Rep.* (1931).

## NOTE

### BROWN CANKER OF ROSES IN ENGLAND

In October, 1931, several rose plants were sent to me from Gloucestershire with the complaint that in the previous June many rose plants in the garden had wilted and collapsed, the wood showing a large amount of die-back.

The specimens bore conspicuous buff-coloured cankers with purple margins, the cankered surface being dotted with the protruding beaks of perithecia, usually in circles surrounding pycnidia. These fructifications agreed with the published descriptions of *Diaporthe umbrina* Jenkins (*Journ. Agr. Res.* xv (1918), 593 and xlii (1931), 293) and specimens forwarded to Miss Jenkins by the Ministry of Agriculture's Plant Pathological Laboratory were compared with material from the United States and found to correspond closely.

I found that cultures obtained from the cankers were also pathogenic to rose shoots, producing characteristic cankers.

The disease, commonly known as "brown canker" in the United States, does not appear to have been recorded previously from this country. It is considered to be the most destructive disease of roses in the United States.

L. OGILVIE.

# REVIEWS

*The Rust Fungi of New Zealand together with the Biology, Cytology and Therapeutics of the Uredinales.* By G. H. CUNNINGHAM. Pp. xx + 261. Figs. 177. Privately Printed by McIndoc, Dunedin, N.Z. 1931. Price 30*s*.

Dr Cunningham has added to his many writings a very useful volume with the above title. The manuscript was completed in 1929 and revised after an extended tour abroad. The publication appears to be a private venture and we may hope that enthusiasm linked with industry will give satisfactory financial results.

Beginning with a seven-page glossary of concise definitions the main body of the work is divided into two parts, the first containing ten chapters and bearing the secondary title as a heading (pp. 1–107), the second the "Systematics of the New Zealand Uredinales" (pp. 109–228) and ends with a full bibliography and index.

The first part opens with a readable and clear summary of the life-histories of the different kinds of rusts, followed by an account of the germination and viability of spores; the attack on the host plant is next considered. A chapter on dissemination and perpetuation of rusts shows how far we have progressed in our ideas on this matter during the last twenty years. A chapter on parasitism gives the main facts while in one on biologic and physiologic specialization the author is at his best for here he has an opportunity of showing a characteristic independence of judgment when collating taxonomy and the results of inoculation experiments. The revision of present day knowledge on *Puccinia graminis*, *P. coronata*, *P. Elymi*, *P. glumarum*, *P. anomala* and *P. Sorghi* is valuable in stating the facts but it also shows the author's point of view. There can be no doubt that "specialization" has been master of the rust establishment rather than the hand-maiden and this in spite of a fairly constant opposition and one mainly from phytopathologists; moreover results obtained in one continent have been blindly assumed to hold for every other. Whether the author has gone too far in relying solely on morphology is a matter on which there is sure to be divergence of opinion, for little has been done yet to precise this morphology.

A comparison of this chapter with the one on rusts in Brooks's recent *Plant Diseases* will show the difference in outlook—a difference which allows one still to believe that much remains to be accomplished before we have clear ideas on some of the fundamental problems of taxonomy.

After a chapter on Therapeutics the author gives his ideas on Phylogeny: he believes heteroecism to be primitive and Melamsporaceae the most ancient group. This part of the book ends with a chapter on Technique and one on Classification.

The systematic portion seems to be a business-like account of New Zealand species. There are comparatively few genera and, as one would expect, many form-species. A large number of species have been described by the author since 1922 and it is useful to have their descriptions gathered together.

The species are described in a concise way, with full synonomy, distribution and relevant notes on the host-plants; line drawings of spore forms are given often with an outline sketch of the aecidium. There are also keys to the larger genera.

The book will probably have a stimulating effect on the study of New Zealand rusts and all the more because its size is about right for the sort of pocket popular overseas.

J. R.

*The Genera of Fungi.* By FREDERIC E. CLEMENTS and CORNELIUS L. SHEAR. Pp. iv + 496. Plates 58. Large 8vo. Published by the H. W. Wilson Co., New York. 1931. Price 50*s*.

Clements's *Genera of Fungi* in its first edition (1909) was much used by students and the present edition will doubtless have a more extended appeal, for not only

is it so much enlarged and altered as to be virtually a new work, but the collaboration of Dr C. L. Shear means there is much that has to be considered by the professional mycologist. The increase in size is shown in the number of generic names, the 2909 included in the first edition have become more than 5000; the number of pages has increased from 227 to 496. The Introduction occupying nineteen pages makes very interesting reading; whether one agrees wholly with the *obiter dicta* or not there are many statements which were well worth making and which would repay commentary.

The following paragraph has determined the line and scope of this review:

"In the hope of furthering the work of mycologists and pathologists the world over, it is definitely planned to issue a new edition of the present book at intervals of three to five years, depending somewhat upon the amount of material that requires attention. In addition to incorporating new and valid genera and determining synonyms, this will also take account of the general progress in the field of systematic mycology. Constructive criticism, both in general and in particular, will be welcomed and utilized, as well as other suggestions designed to render the book more serviceable."

The book will meet with different receptions according to the use to which it is to be put but it is unlikely that it will be regarded as satisfactory by many who have specialized in the taxonomy of particular groups: this probably would be true of any similar attempt to that of the authors but with the assistance asked for it ought to be possible to improve each edition.

The first criticism applies to both editions. It is unscientific—in the present lack of knowledge—to use the names Protococcales, Spirogyrales, Vaucheriales and Confervales and to give the description of the corresponding algal groups for three of them and to modify that of the Vaucheriales to include fungi. There is also no warrant for shortening sesquipedalian names and to change even such names as *Raciborskiomyces* to *Chaetobotrys* is uncalled for; to alter well-known names like *Helicobasidium* to *Helicobasis* is ludicrous nonsense.

The Key to the Genera occupies about 200 pages. In spite of the philosophical discussion on dichotomous keys it appears to me that the authors have fallen into error, though of a different kind from that of placing Uredineae in Ascomycetes, as in the first edition. It is the old story of the Sabbath and Man so misinterpreted in parts of the British Isles and the U.S.A. The dichotomous key is not a preordained pattern into which genera have to fit as they were allowed for in Saccardo's scheme, which some have regarded as based on almost as sound reasoning as Mendeléeff's periodic classification of the elements. It is self evident that the fewer the distinguishing characters chosen the fewer will be the genera which prove amenable to keying. Given the generic characters it should be possible to arrange these so that all the genera of a family would fit in. It is because this seems not to have been followed out logically that several genera have fallen into synonomy or have been listed twice or more.

An innovation in the present edition is a List of Types and Synonyms occupying about 180 pages. This is very welcome but is likely to be the most criticised portion of the work. If, however, the types are regarded as tentative the list should serve a useful purpose.

The first thing to be gathered from the list is the large number of genera which have been omitted from the key either as doubtful or as synonymous. The grouping of some genera as "*Genera incertae sedis vel dubia*" should be altered in future editions because of ambiguity. There are some genera here which are well-known, e.g. *Glischroderma*, but which may not be easy to place; others such as Maire's genera *Rhodocybe*, *Rhodopaxillus* and *Rhodotus* (to take three which follow one another) are split off from genera which are in the keys and so should be entered under them; others again have no existence in fact, e.g. *Volvoboletus*, *Mycodendrum*.

In a further edition some indication about the equivalence or otherwise of synonyms would be useful to students; in other words those depending solely on nomenclature and those into which considerations of taxonomy enter. That the names have been used for the same generic concept can be gathered sometimes

from the fact that the same type species is given but a synonym may be merely a reincluded genus, or may be any extension of the original genus. Thus *Lamprospora* and *Barlaeina* (*Barlaea*) are based on *Peziza miniata*; *Stromatinia* is reincluded in *Sclerotinia*; *Pithyella* (Inoperculatae) is for some reason given under *Pithya* (Operculatae).

Without entering into such matters as whether Thaxter (and Fitzpatrick) should be followed in sinking *Empusa* in *Entomophthora* or the wholesale slaughter of Boudier's genera there is far more that seems to warrant criticism than can be treated here.

In spite of the number of synonyms some genera have received excessive consideration. Thus *Pimina*, *Urobasidium*, *Urophiala* and *Zygosporium* are all the same genus; *Protocoronospora* (*Protocoronis*!) should join *Aureobasidium* (*Aureobasis*!), *Exobasidiopsis*, *Kabatiella*, *Pachybasidiella* and *Polyspora*; *Colletotrichum* and *Vermicularia* are congeneric; *Aspergillopsis* Speg. (non Sopp) and *Rhopalocystis* are equivalent in every way; *Engleromyces* is sunk under *Sarcoxylon* but *Colletomanginia*, the same genus, is upheld but changed to *Cerillum*; *Emericella* and *Inzengaea* are synonyms—Massee considered this genus to be a Gasterolichen!

The wrong choice of generic name is sometimes made, e.g. *Basisporium* Moll. instead of *Nigrospora* Zimm. here because the first reference to this, *Central. f. Bakt.* Feb. 1902, has been overlooked.

Some unnecessary genera are given apart from those like *Asterophora* and *Coremium*; *Helolachnum aurantium* is *Helotium luteolum*; *Medusomyces* is a mixture of a *Saccharomyces* and *Bacterium xylinum*; *Histoplasma*, first described as a protozoon, is *Cryptococcus* sensu Vuillemin.

Many genera are omitted; e.g. *Arthroderma* which antedates *Ctenomyces* and *Harzia* and its synonym *Eidamia*.

The volume ends with a bibliography of nineteen pages, a most useful Glossary of Latin and English terms (thirty pages), and an index and fifty-eight plates. It is difficult to review, for every few pages one finds points on which one radically disagrees but a bald statement without reasons is not satisfactory particularly as the authors have had no opportunity of explaining details. It would be interesting to have their explanations for some of the lumping in which they have indulged for it cannot be that it is solely because the genera happened to fall together in the key.

J. R.